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No. 1

MEASUREMENT OF RIVER DISCHARGE¹

By J. B. SPIEGEL²

By authority of the organic law the United States Geological Survey was empowered to investigate the mineral resources of the nation. Since water is a mineral the surface flow of streams is properly made official business.

This particular work was commenced in the United States in 1888 in connection with studies relating to irrigation in the west. In the course of time the value of these data increased and their field of usefulness grew until today they assist in the solution of problems that affect every citizen. The number of measuring stations in operation has grown from a few in the early 90's to nearly 1700 this year. During the fiscal year of 1924 there were made approximately 12,000 regular and miscellaneous discharge measurements. These statements refer only to work done by the Water Resources Branch of the United States Geological Survey and coöperating parties.

River discharge records are secured by means of a gage to determine the surface elevation of the stream and a meter to obtain the velocity at which the different portions of a plane cross-section of the river move.

It is advisable to begin work with a reconnaissance survey of the river observing especially

¹ Presented before the Iowa Section meeting, November 7, 1924.

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1. The character, the sensitiveness and the location of the control section with reference to the proposed site of the gage.
2. The general course of the stream above, at and below gage site.
3. The proximity of tributary streams and artificial obstructions that would influence the stage-discharge relationship.
4. Whether the bed is shifting or permanent.
5. Whether the banks are high or low, wooded or clear, permanent or changing.
6. The availability of competent gage observers.
7. The most appropriate type of gage.
8. The available or required structures from which to make discharge measurements.

The examination should be made when the stream is at low stage in order to obtain a more detailed inspection, although a knowledge of conditions at all stages is very desirable. No expensive installations should be made until a selected site has been proven satisfactory. In general, the procedure after the gage site has been selected is to install a non-recording type of gage and depend on an observer to obtain several gage readings a day.

Non-recording gages that are ordinarily used are of two types, namely, the chain and the staff. In Iowa the chain gage is preferable because of the great range of stage in its streams and the convenience of bridges. It is less difficult to install, read and maintain and is generally more accessible.

The essential parts of such a gage are a graduated scale 10 feet in length, a small sheave about 3 inches in diameter, a link-chain, and cylindrical iron weight about a foot long and $1\frac{1}{2}$ inches in diameter. The zero gage reading is so selected that the probable extreme minimum stage will have a positive reading. The determination of datum elevation is largely a matter of the judgment of the engineer in charge. Durable bench marks are then set in places not subject to disturbance. A mark is placed in the chain opposite the gage reading, which equals the height of the level sight. This is accomplished by moving the weight vertically until the bottom of it is cut by the line of sight of the level the elevation of which is known. As the scales are placed in a horizontal position a sheave is used to change the direction of motion.

The rivers of Iowa have changes of stage from 15 to 25 feet. In order to provide for readings over the 10 feet to which the scale is

limited a second and third marker are placed on the chain, the three being 10 feet apart. Thus, if the river should rise to $12\frac{1}{2}$ feet the second marker would be used and a reading of $2\frac{1}{2}$ feet would be obtained and by the addition of ten the correct reading is recorded.

A record of stages, however, is only of limited value. The actual discharge in some definite unit such as the cubic foot per second is the basis for water supply studies. The control being, in general, a natural formation, no empirical formula can be applied as one may for weirs or other artificial measuring devices. Consequently it is necessary to discover a stage-discharge relationship. To do so the flow must be measured at various stages which cover the range of fluctuations. The special instrument used for such a measurement is called a current meter. It is a delicately balanced wheel so shaped that it is whirled by the passing water. The completion of each revolution is detected by means of an electrical contrivance which causes a click in a receiver. At the snapping of a stop watch the revolutions are counted, the number being usually some decimal value, such as 40, 50 or 60. The watch is then stopped and the time interval observed. The meters are rated at some laboratory by passing them through still water at different speeds and a table computed which gives the velocity for various revolution-time combinations.

The Price current meter is most generally used by the United States Geological Survey. It is rated for combinations between 5 and 200 revolutions in time intervals of between 40 and 70 seconds.

Low stage discharge measurements are usually made by wading. A longitudinal section of the river is selected that approaches nearest the ideal one in which the flow lines are parallel and of uniform speed and depths of the cross sectional area are equal. The bed of the stream should be solid and smooth.

Rarely can all ideal conditions be found and so the engineer makes the best of what he has. A tape or some other marking line is stretched across the stream and fastened. It serves to guide one in the plane section and to space his depth and velocity measurements.

Proceeding from either edge the depths are measured at chosen intervals and if they are less than $1\frac{1}{2}$ feet the current meter is placed at a point 0.6 of the depth below the surface, if more at 0.2 and 0.8 of the depth and the velocity determined.

The entire section being thus tested and notes recorded there remains only the computation of the sectional discharges and their addition to find the total discharge.

The area of each small section is equal to the average depth times the space interval used and the average velocity of the same section is the average of the velocities found in the planes in which the depths measurements were made. Since velocity is reckoned in feet per second, the product of the area and the velocity gives not only the cubical content but the time interval under consideration and thus furnishes the discharge value in a desirable unit.

Discharge measurements are made at each visit to the station by an engineer and the corresponding stages are noted. By plotting the values coördinately there results a rating curve which shows the stage-discharge relationship which furnishes an easy means of determining the discharge for any gage height in question. The average discharge for the day is obtained by applying to the rating curve, or more conveniently to the rating table, the average gage height for the day. The flow for the week, month or year of course is simply a summation of the daily discharges encompassed in the period.

Higher stage discharge measurements are made essentially in the same way as by wading. The engineer works from an especially equipped cable and car which are suspended well above extreme flood stages, or more generally from bridges. The distance across is marked off in parts best suited to the shape of the cross section of the stream bed below. Depths are obtained by letting a 10, 20 or 30 pound torpedo shaped weight to the bottom and observing the length of cable hauled in when the weight just skims the surface of the river. These weights are also used to hold the meter at desired depths from the water surface. Velocities are obtained in the same way as by wading except that observations are not made at 0.2 and 0.8 of the depth for depths smaller than $2\frac{1}{2}$ feet. This is due to the fact that the arrangement of the equipment prevents lowering the meter to within $\frac{1}{2}$ foot of the bottom.

During the time which elapses between the establishment of a station and the securing of sufficient discharge measurements to define a rating, the engineer can collect sufficient information to enable him to decide on its stability. If it is satisfactory and it is desired to increase the refinement of the gage record, a continuous stage recorder should be installed. Mechanical stage recorders are necessary:

1. Where water is valuable and accurate records are very important.
2. Where sudden changes in stage occur.
3. Where records are desired on a stream that is dry most of the year but is subject to floods.
4. Where records are desired on a stream that flows continuously but is subject to floods.
5. Where it is necessary to determine the maximum gage height or the maximum daily mean gage height.
6. Where it is necessary to determine the minimum gage height or the minimum daily mean gage height.
7. Where the information is or may be used in the adjudication of water or the settlements of other water problems by the court.
8. Where gage readers are unsatisfactory.
9. Where gage readers are not available.
10. Where flood warnings of a specific nature are needed.

It has always been the aim of engineers to obtain accurate records and wherever their importance is known or can be foreseen and funds will permit, the non-recording gage is replaced by one which operates mechanically.

The cost of installing such a gage varies greatly and depends on the kind of structure built, its location and the kind of instrument used.

The recording gages first produced did not fulfill the needs of stream gaging, but in the last fifteen years most of these troubles have been eliminated and during the same time experience has enlightened the engineer on the best methods for installing the machine. But perfection is still out of reach and even today men are discussing and experimenting for further improvement.

Mechanical recorders on streams heavily laden with silt, such as our streams are at times, were tabooed because of the difficulty in maintaining an open intake. The problem is still vexatious but the addition of some extra plumbing enables the observer to flush any interfering deposition at all probable stages of the river. There are several good makes of recorders and each has advantages that are appealing. One machine we use is so built that it provides for even the shrinkage or expansion of the paper upon which the record is traced.

While greatest attention has been given to the gage height record in recent years, considerable thought has been directed toward the

making of more reliable discharge measurements. I believe it may be safely said that the major number of measurement are made from bridges. These are never designed for stream gaging purposes and one cannot expect to obtain best results. In many cases one or more piers obstruct the flow. At their footing are left the remains of coffer dams and on their noses the debris of previous or existent floods. Under such disturbed conditions it is not to be wondered that the data collected give erroneous results.

Again, if funds permit, a cable station is erected at a place where water flows uninterruptedly in one channel, where possible. The section should be wide and velocities moderate. The bed should be comparatively smooth. Such a section usually does not serve for wading measurements.

I have attempted to cover only in a general way the method and means for measuring the stream flow.

A detailed account of this topic is clearly and thoroughly given in the treatise called "River Discharge" by Hoyt and Grover. The regular work of stream measurement is interesting, but when the field of special conditions is entered then it becomes most absorbing of thought and attention.

HYDROLOGIC RECORDS IN IOWA¹

BY F. A. NAGLER²

The hydrology of the streams of the middle western states, which have been relied upon in the past to furnish an abundance of pure water for many of our cities built on their banks, has, in general, interested water supply men but very little. The supply was abundant and the water could be treated so that it was usable, and what more should be desired? But, with the ever increasing pollution of our middle western streams by factory and city waste, making it more difficult to secure safe and usable water, an accurate knowledge of the quantity, variability and distribution of the water resources of the state at once becomes a matter of prime significance and interest to water works men. It may be only a matter of time until many Iowa municipalities may be forced to seek their water supply from the flow of water off small watersheds which they can protect from all manner of dangerous pollution, as is the prevailing practice in New England. A marked difference, however, between the New England and Iowa streams as water yielders will be noted. With an average annual precipitation of 32 inches on a representative Iowa stream in contrast to a possible 40 inches over a corresponding New England watershed, the Iowa stream ordinarily yields only 8 inches of runoff annually, with water losses amounting to 24 inches; whereas, if the New England watershed is forest covered, its water losses may be only 20 inches giving a stream yield of 20 inches—two and one-half times as much water as that yielded by the typical Iowa stream.

The investigation of the water resources of a given watershed is facilitated by the use of hydrologic records of various sorts. Primarily, one is interested in the daily record of stream flow, but this should also be supplemented with records of precipitation. If the water supply project involves the storage or impounding of water, evaporation records are of significant importance. However, ade-

¹ Presented before the Iowa Section meeting, November 7, 1924.

² Associate Professor of Mechanics and Hydraulics, University of Iowa, Iowa City, Ia.

quate records of precipitation, stream flow and evaporation cannot be obtained in a day. If you had read between the lines of Mr. Spiegel's paper³ you learned that the acquisition of what meager stream flow data we have on the behavior of the Iowa streams has meant a struggle with little or no substantial coöperation from those interested in Iowa streams as a source of water supply. For a long period this work was supported mainly by the Power Company at Keokuk, and more recently the Iowa Geological Survey and State Highway Commission have also aided. The people of the State of Iowa sooner or later must become interested in their own water resources not *only* as a source of power, for there is comparatively little in the State of Iowa, nor only for the design of bridge openings, flood protection, and like enterprises, but primarily as sources of municipal water supply. An adequate stream flow investigation program for the state should be supported by an appropriation by act of the legislature, instead of continuing on the present country church basis, when each year the question is raised whether the work will not have to abandoned because of the lack of contributions from the various sources.

Assuming that a ten-year record of stream flow is the minimum length upon which a reliable estimate of the probable yield of a stream can be made, there can be found only five continuous records of stream flow in this state of longer duration than this. The only one really adequate record of stream flow is that of the Cedar River at Cedar Rapids which has been maintained continuously for more than twenty-one years. If the present twenty-seven stations maintained by Mr. Spiegel can be continued, an excellent network of stream flow data distributed over the entire state is assured for the future. It would be desirable, however, if considerable extension of this work could be made toward establishing gaging stations on a number of areas draining less than 500 square miles. Only three records on small streams are at present being maintained. One is kept by the Mississippi River Power Co., in coöperation with the United States Geological Survey on Sugar Creek near Keokuk, Iowa and the other two are maintained by the United States Geological Survey on the Skunk River and Squaw Creek near Ames. It is from such small areas that some Iowa municipalities may be forced to look for an unpolluted water supply, and at present there is an absolute dearth of information as to the yield of these small catchments.

³ See This JOURNAL, page 1.

The United States Weather Bureau with the aid of its coöperative observers located in each county are able to furnish as good data with regard to Iowa precipitation as can be found in most states. The longest record in the state is that which has been kept at Muscatine continuously for seventy-nine years. There are, however, seven records which are continuous for a period of more than fifty years, and nineteen places where records have been kept continuously for more than thirty-five years. A record over twenty-five years long can be found in almost every county in the state. Yet, if a municipality were contemplating the acquisition of a supply from a small watershed it would be well to establish several additional rainfall stations within the watershed.

Unfortunately there has been little or no interest displayed in the subject of evaporation from free water surfaces within the State of Iowa. At the present time there are no Class A, Standard United States Weather Bureau Evaporation Stations being maintained and the only past record of evaporation measurements which has come to the writer's attention has been that kept by Prof. A. G. Smith during the years 1906 to 1910 at Iowa City. Evaporation records of value could easily be maintained in pans floating in our open air reservoirs, similar to the record which has been kept continuously since 1891 in the Mt. Hope Reservoir of the City of Rochester and at Chestnut Hill Reservoir, Boston and elsewhere.

The Hydraulic Laboratory of the State University of Iowa has very recently started a project studying the factors affecting run off from a small drainage area east of Iowa City. The coöperation of the United States Department of Agriculture has been enlisted in this study which will tend to give it stability and permanence. The small area tributary to the north branch of Ralston Creek as it enters the city limits at the east side of town has been carefully surveyed, producing a large scale map bearing 5-foot contours upon which the boundaries of the small drainage area are easily defined. At the point where the creek crosses the Rochester Road, a permanent weir and water level gage have been installed to obtain a continuous measurement of the yield from 3.03 square miles of area which drains into the creek above this.

Eight rain gages have been located on the watershed, one being a recording gage in order to observe the intensity as well as the amount of the precipitation. Observations on ground water level are taken at regular intervals in seven dug wells located at different points on

the watershed, in order to determine the condition of the ground water storage and its relation to stream flow.

The watershed is remarkably uniform in its general topography, being mostly very hilly with side slopes averaging 100 feet per 1000. Thirteen per cent of the area is timbered, and about 50 per cent is annually under cultivation, the balance being unused or in pasture.

Although such a small watershed could possibly yield only an average of 500,000 gallons per day if used as a source of water supply, there are many advantages to be gained in making the hydrologic study on a basin of this size and many of the complicating factors are eliminated which have arisen in the past study of larger basins and have defied analysis.

By the continuation of these observations, together with surveys of soil conditions, crops and evaporation, it is hoped that much data of value will be obtained which will be invaluable in the determination of the yield of Iowa streams, low water flow, and flood run-off from intense storms.

SANITATION ON THE CATSKILL WATERSHEDS¹

BY THADDEUS MERRIMAN²

Among the various questions which confront those who are charged with the responsibilities of maintaining the quality of a public water supply is that which relates to the sanitation of the drainage area within which the water originates. Filtration will improve the quality of any water and, when used in combination with chlorination, will make the worst of waters potable. But there is a large and ever-growing sentiment against the use of these processes for making a bad water good. The consumer would far rather see them employed for the purpose of improving the quality of water that was already above reproach. In other words, the present tendency is toward the prevention of pollution, and this in turn means that more attention must be paid to the sanitation of our watersheds.

The doctrine of riparian rights which is the basis of the laws relating to the use of water in most of the states east of the Mississippi may be stated as follows: The riparian owner is entitled to have the natural flow of the stream pass through his property undiminished in quantity and unimpaired as to quality. This, of course, is the most that he can expect. If he himself lived up to the doctrine he could use none of the water and could not even interfere with the regimen of flow as in a water power. Neither could he do anything which might change or alter the quality of the water.

The effect of this doctrine is to impose an obligation on every riparian owner, while at the same time it confers upon each such owner a right as against all upper riparian owners. These rights may be of great value, yet they cannot be exercised except in a reasonable manner. Similarly, while the obligations imposed may be onerous, they cannot be insisted on except as they are themselves reasonable. And so it has come about that the principle of reasonable use is generally applied to all such cases. The answer to the question as to what constitutes reasonable use must be based on the facts and the circumstances of each particular case.

¹ Presented before the New York Convention, May 22, 1924.

² Chief Engineer, Board of Water Supply, City of New York, N. Y.

The health laws of our states abound with prohibitions as against what shall not be done in the way of polluting our water courses. But the law is silent as to how an owner may use or to what extent he may contaminate the water which comes to him and flows over his land. He can secure redress as against an injury only if he can prove that he has been damaged. Local boards of health are often lacking in sympathy and one who raises up his voice because the water which is supposed to come to his lands pure and undefiled does, in fact, arrive as more or less diluted sewage is immediately set down by a large part of the community as one who complains unnecessarily. More especially is this so when a municipality attempts to protect itself against the pollution of its water supply. The diversion of water from one locality to another is, from the point of view of those within the watershed, an unreasonable thing because it constitutes an invasion of their territory and an interference with the rights they have so long enjoyed without let or hindrance and without feeling that damage was being done to anybody.

This, then, was the position in which the Board of Water Supply of the City of New York found itself with respect to the general question of sanitation on the Catskill Mountain watersheds. The existing health laws were cumbersome and unwieldy. The sentiment of the people on the watersheds was opposed to the enactment of any measures which might result, by interfering with the convenience of the moment, in any expense whatever. This feeling, moreover, was fostered by an agitation founded on the belief that if such pollution as there was could not be removed, the City in self-defense would be compelled to buy up the entire area of the watersheds.

The first step looking toward the relief of the situation was that which resulted in securing, through legislation, the right to promulgate rules and regulations as to proper sanitary conduct and behavior, these rules to become effective after approval by the State Health Department and after due advertisement. Shortly after the promulgation of these rules arrangements were made with various private owners whereby the City was permitted to enter upon their lands and, without cost to the owner, make such changes and improvements as were necessary. It was then not long before individual opposition dwindled and disappeared, but the agitation looking toward the acquirement by the City of all the lands in the watershed continued.

The situation with respect to the individual owner being thus provided for, the next step was that looking toward the installation of sewerage systems in those villages which were possessed of public water supplies. The first bill seeking to authorize the City to undertake such constructions was introduced in 1914. It was strenuously opposed on many grounds, among which the following may be of interest:

- a.* The procedure proposed is unconstitutional.
- b.* The expense sought to be imposed on the individual property-owner will be so great that the net result will be a confiscation of his property. In consequence of this condition, all of the lands in the watershed will be so depreciated in value that in fact they will have no value at all.
- c.* The proposed provision for the exclusion of rain water from the sewers is impossible because it would mean that the sewerage systems, if built, could not be used. All waters originate as rain water.
- d.* The climate in the Catskills is rigorous. Every winter all modern plumbing in every house would freeze and so entail great expense on every owner. On account of the great depth of frost penetration the sewers themselves would freeze and break. The resulting overflow of vile and putrescible matter would cause disease and pestilence to flourish in these beautiful and now healthful communities.
- e.* The large volume of sewage which would be collected by such sewerage systems could not be purified by any means known to science. The effluent, even if purified to the greatest possible extent, would utterly ruin and destroy the river channel all the way down to the Hudson and render uninhabitable large areas of country on both sides of the river.

With such irrefutable arguments (!) at their command the objectors prevailed and the matter was permitted to rest. In the meantime at least one of the villages began to see the necessity of providing a sewerage system on its own account and it then became no difficult matter to secure, in 1923, an enactment giving to the City the right to construct sewerage systems, provided that suitable agreements could be made with the authorities of the villages concerned.

The main points of the enabling act, Chapter 630 of the Laws of 1923, are as follows:

1. The City of New York may contract, with the authorities of any village located in the Catskill Watersheds, as to the construction of a system of collecting and disposal works.
2. The City must pay all costs of the system, including house services up to the cellar walls of all buildings, and must operate and maintain the system forever.
3. The individual owner, when the sewer has been completed, must connect at his cellar wall with the house connections provided by the City.
4. The City is empowered to acquire any and all lands necessary to make the plan agreed upon with the village authorities effective.
5. The City, after the plans have been approved by the State Engineer, is authorized to use the public highways, roads and streets, provided only that satisfactory repairs and replacements are made.
6. The moneys necessary for the carrying on of such works are to be obtained by the sale of corporate stock of the City of New York, such corporate stock being deemed to be bonds of the City issued to provide for the supply of water.

At the present time negotiations with one village have been well advanced, and it seems probable, as soon as the other villages become aware of the benefits to be derived by a proper disposal of their sewage, that they will themselves petition for relief just as the individual property-owners did when they saw their neighbors securing what they considered to be benefits.

There is little doubt as to the equities on which this enabling legislation is founded. The operations of the City of New York from the viewpoint of the people in the watershed are unreasonable. Theirs is an individual use of water and theirs is an individual pollution. The City's use is wholesale, and if such individual pollution as exists is detrimental to the City, it can be removed only at the expense of the party which benefits through the use of the water. The doctrine of reasonable use applies with equal force as between two individual owners and as between a great corporation and a single individual. The necessity of the municipality cannot be held to impose an added obligation on the private owner. Neither should the fact that the municipality must defend itself with respect to the quality of its water supplies be permitted to impose on it any unjust burden.

WATER WORKS DISTRIBUTION SYSTEMS¹

BY W. E. MACDONALD²

Distribution systems should be so designed that they will be able to supply adequate quantities of water to all consumers, with economy and with reasonable security against interruption to service. With respect to the design of this part of a water works system, the uses of water naturally fall into two classes: First, the ordinary, every day use for domestic, commercial and public purposes; and second, the use for fire extinguishment. In the former case the consumption is relatively uniform over different portions of the city, and is also well distributed over many hours of the day; in the latter case, however, the rate is likely to be extremely high for a very short period of time, but this excessive use of water will usually be confined to a very small area. To supply water in the former cases requires the wide distribution of moderate quantities, while in the latter case the problem is rather the concentration of large volumes within a narrow district, which district might be located in any part of the whole system.

The method frequently adopted for improving the pressure in a distribution system is to encircle partly or wholly the whole area by a large feeder. This scheme tends to equalize the pressures around the circumference and, if the general pipe grid-iron is well balanced and of adequate capacity, it is an economical and effective method of accomplishing the results.

As a general rule, however, in most cities the mains 10 inches in diameter or over are widely separated in many sections, while usually over 50 per cent of the inter-connecting system consists of 4- and 6-inch mains. These small pipes are all right as far as the requirements of the normal domestic service are concerned, as the consumption is relatively uniform over different portions of the city, and the loss of pressure in the distribution of the moderate quantities of water

¹Abstract of paper read before Canadian Section meeting. Complete article in Canadian Engineer, March 4, 1924.

²Water Works Engineer, Ottawa, Canada.

required is correspondingly small. In the event of a bad fire, however, large volumes of water must be concentrated within a small district, which may be situated at any point of the system. Under these circumstances the draft for local domestic purposes in the immediate vicinity of the fire, say within 1000 to 1500 feet, is almost negligible compared with the quantities the pipes must carry for fire streams. When we consider that the loss of head in a 4-inch pipe, carrying sufficient water to supply two standard streams, is from 25 to 30 pounds in the length of the ordinary city block, it will be apparent that, if excessive losses of head are to be avoided at the running hydrants with a fire in progress, provision must be made for feeding the small street pipes at frequent intervals from the large mains. Consequently I have found that the improvement in pressure that would be effected by the means of a large main encircling the most important part of the city would not be uniform, that is, the territory immediately adjacent to this large feeder might have very good fire service, but the pressure in other sections remote from the feeder, while no doubt much better than formerly, would still be far below the standard. It has been determined that the only way the high local losses may be avoided and satisfactory fire pressures maintained is to feed the 4- and 6-inch grid-iron from parallel mains, crossing any area at regular intervals of from about one-quarter to one-third of a mile. These mains should be laid in the direction that will be best suited for their future extension to serve the outlying districts. Wherever possible these pipes should run to the centers of the sections which require the highest pressures, whether on account of elevation or the character of the local fire risk, and should follow such routes as will best avoid expensive rock excavation, or the interference of permanent pavements and street car lines.

In regard to the smaller pipes (with street intersections from 300 to 600 feet, it is generally found that 6-inch pipe will be satisfactory in residential sections, 8- to 10-inch in semi-commercial sections, with the highest buildings about five stories, and 10- and 12-inch in the principal business section where the buildings will eventually be from eight to ten stories. Many special cases, however, will occur where the necessity of larger mains will be apparent, as for example a street at the extreme outside of a district which is supplied from one side only or a street paralleling a railway siding.

One of the most important items, and one which very often receives slight attention, is the proper location of gate valves in the supply

system. In the opinion of the writer it is essential that valves be installed at the following locations.

A valve should be placed on a main pipe immediately after it leaves another main which feeds it, and also immediately after all branches 12-inch and over are taken off it. Where the branches are small, such as 6- and 8-inch, valves should be placed at least as often as every fifth pipe branch or crossing; on all branches leading to hydrants and where the mains run parallel to the long side of the city blocks, at every third crossing, where the pipes are laid under water, through railway property or similar places of special risk there should be valves provided at both ends of these sections, in order that prompt shut downs may be made in case of rupture to any part of the system. All valves should be placed in suitable chambers that provide sufficient room for repairing and packing of valves.

Automatic air valves should be located on all large mains at extremely high points to take care of the filling of the mains and to prevent water hammer; while properly trapped drain-out valves connected directly to sewers should be provided at low elevations to assist the work of draining out various sections.

Where private pumping systems are directly connected to the city pipes it is positively necessary for the city authorities in charge to insist on the installation of double check valves of an approved design to safeguard the city supply, and thereby prevent any foul or untreated water from entering the city system.

Another important factor in the effectiveness of a system for fire protection purposes is the proper spacing of fire hydrants. The loss of head in 100 feet of ordinary $2\frac{1}{2}$ -inch hose, carrying one stream of standard capacity, is practically equal to the loss of head in a distance of over 1000 feet along the larger mains when carrying the maximum supply for fire and domestic consumption. This means that over a level section as good results may be obtained from hydrants spaced 400 feet at a distance of 4 miles from the pumping station as from hydrants spaced 600 feet apart only 2 miles distant from the source of the supply.

In residential sections, it is good practice to install hydrants at all intersections with a maximum spacing of 500 feet, while in commercial sections from 200 to 250 feet is recommended.

The fire hydrants used should be of an approved type possessing the best mechanical features, with the hose connections and method of operation standard with the remainder of the system. In setting

the hydrants care must be taken to see that provision is made for the proper draining of same to prevent freezing during the winter season.

For the distributing system, iron is the only reliable material of assured length of service. When the pipes exceed 36 inches in diameter, as is frequently the case for large cities in mains leading to and from the pumping station, a cheaper material may be used, as steel or lock-jointed concrete pipe. The life of steel pipe depends upon its protective insulation to a great extent and the pipe should be carefully dipped in a protective solution and wrapped with impregnated hessian or burlap. Reinforced concrete pipe having lock and expansion joints was used on the gravity water supply system at Victoria successfully under 50 pounds pressure, and on part of the supply system for Winnipeg. Iron pipe has been in use in Aberdeen and Paris for over two hundred years. Until recently only cast iron pipe has been used extensively, but there is now offered for sale pipe made by the centrifugal method. Comparative tests made at the University of Toronto of 6-inch centrifugal and cast iron pipe showed the centrifugally made pipe to have about double the strength of the ordinary pipe, while the thickness was less than half.

When it is proposed to make extensions in Ottawa to the existing system, the engineer-in-charge has a report prepared with detailed plans showing the cost of construction, the required revenue and the estimated revenue from the property served by the extension. The work having been duly authorized, the engineer then selects competent foremen to carry out the work, and issues an official work order, to which is attached a blue print of new extension, showing the location and size of pipe, valves, hydrants and specials.

These work orders contain detailed instructions to the foreman and state definitely the amount of material he is permitted to obtain from the corporation store. These work orders are made out in triplicate; one copy is retained in the engineer's office, one is sent to the store-keeper, and the third is forwarded to the foreman.

The engineering department purchases all material and supplies in excess of \$200 by tender. All cast iron pipe, gate valves, meters and special pipe castings are required to undergo a hydrostatic test under an official inspection before shipment. However, as a second precaution against the possibility of leaks developing the engineer insists on all new pipes being tested before any backfilling is allowed. To facilitate the work of field testing the department have had manufactured special testing plugs for all sizes of pipes, which permit testing at short intervals with the least delay.

There are few works which require greater care and more constant vigilance on the part of its employees than does the operation and maintenance of a public water supply. To maintain an uninterrupted supply it is necessary for the engineer to build up an organization of highly trained men to carry out the various branches of service. Under the operation and maintenance, there are to be considered, in addition to the question of construction already referred to, the following appurtenances, general repairs, inspection and maintenance of fire hydrants, valves and meters, prevention of electrolysis, thawing of frozen services, and finally the systematic survey for the prevention and detection of leaks.

For repairs the water department should carry a complete stock of all materials and plant necessary to effect repairs promptly to any part of the system irrespective of the time of day.

All valves should be inspected at least once annually for the detection of leakage and to ascertain if they are in proper working order. The stuffing boxes require to be regularly packed, gearing lubricated and a test made to make certain that all valves are fully open.

Fire hydrants require careful attention, especially in cold climates, as it is of the greatest importance that they be available at all times for use. In the approach of cold weather, all hydrants should be examined and properly packed with a suitable non-freezing material, a test made to see that hydrant properly drains and the valve closes tightly. In very cold climates it is necessary to make almost a daily inspection of hydrants to ensure their good order.

The remedy for electrolysis should apparently rest entirely with the railway companies. There are several means whereby prevention of electrolysis may be secured. The use of the double trolley is perhaps the only complete remedy, while the construction of adequate return wires assists greatly in preventing electrolytic action.

A question which occupies considerable attention of the water department during the winter months is the thawing of frozen water services. There are several methods employed for the thawing of water services, but the only satisfactory manner of performing this work is by use of an electric current. Very often electric thawing has been attempted with disappointing results, due to improper apparatus, either dangerously powerful or inefficiently weak. Not unusually when a freeze-up comes in there is no time to arrange for special apparatus or equipment that might be expected to give the best results, and consequently any material available is pressed into

service, such as ordinary transformers, fuse blocks and cable. Such type of equipment is exceedingly hazardous to the operators and injurious to the service pipes and connections due to the current setting up an electrolytic action.

Prior to the year 1919, the city of Ottawa each year made a practice of thawing all services by the transformer method. Equipment was assembled whereby the current was obtained from 2200 volt primary wires of the power company and stepped down by transformers to a secondary current of 110 volts. This system, although it obtained the water in many cases had its disadvantages. On many streets the primary transmission lines of the company were not available and no connections could be obtained, while the danger of operation was ever present. However, it was not until the summer of the year 1919 that the city of Ottawa was actually confronted with the real danger of this equipment, when at that time a telephone operator at work was electrocuted by coming into direct contact with one of the primary leads of the previous winter.

After this unfortunate affair occurred the matter was brought to the attention of the writer, and after considerable study on the subject I designed a self-contained, electric, portable plant for thawing of mains and services, which I had patented both in Canada and the United States. This apparatus as the name implies, is a self-contained power plant capable of generating 500 amperes of electric current at 30 volts. With this new type of machine it is no longer necessary to make connections to high voltage wires of the power companies, and therefore all danger from this source to both the public and the employees is eliminated.

The city of Ottawa has had in service two of these machines since the year 1920, and they have produced excellent results, having thawed out successfully some 3400 services extending over a period of three years.

This new thawing apparatus has effected a considerable saving both to the Department and to the public, as it has reduced the cost of thawing from \$6.05 per service, by the transformer method, to \$1.78, a saving per service of \$4.27. During the past three years of operation, even allowing for depreciation, the machines have been directly responsible for a total saving in excess of \$14,500, and have been a means of providing prompt and efficient service to the public during the winter season.

The problem of reducing the waste of water, which invariably occurs in all unmetered cities and towns, is receiving an amount of attention from engineers and water works officials equal to that formerly given to the problem of securing additional supplies, when the demands for water bid fair to exceed the capacity of the source in service.

The excessive per capita normal draft in most cities may be attributed to the following causes:

1. Leakage from defective plumbing and fixtures.
2. Unnecessary running of taps.
3. Extensive use of water for power and manufacturing purposes.
4. Leakage from underground system.

In regard to correcting the careless waste of water in the houses much may be accomplished by impressing the citizens with their financial interest in the matter through the medium of educational campaigns.

All water required for power and manufacturing purposes should be sold by meter at an equitable price.

The determination of underground leaks and their repair is a work which takes considerable time and in large cities requires the organization of a separate pitometer branch to conduct waste water surveys.

The use of meters is now becoming much more general and in most cities the large consumers, at least, are now metered, but a very large amount of the loss or waste is due to the small consumer, so that the full benefit of the system will not be felt until the use of meters becomes general.

Procuring and preserving accurate records of all work done in connection with the distribution system constitutes one of the major activities of an engineering bureau. One of the first essential records of a water department should be the preparation of a map showing the size of mains, hydrants and valves. Copies of these plans should be available in the engineering and foreman's offices and in all city fire stations. As it is usually not possible to show in detail the various connections of mains at intersections on the larger plans, it was found in Ottawa advisable to have a set of intersection plans prepared on a scale of 20 feet to the inch, which indicate in detail all connections, hydrant and valve measurements. These plans are bound in loose-leaf books, cross-indexed, and are carried on all trucks of the water department for general use of the foremen in making prompt shutdowns.

PRE-MOULDED REINFORCED CONCRETE PIPE¹

By W. G. CHACE²

The class of pipe most suitable for use as an intake for a water works system should possess as many of the following qualities and characteristics as possible. That there is no fixed practice in the choice of material for such lines is evidence that the ideal pipe is yet to be established in use. The problems to be met are varied and in many cases may be solved only by the use of very expensive and difficult construction. It is not frequently the fact that the trench can be unwatered; it is often the case that the site for the line lies under a considerable depth of running water; often the trench foundation is not of the strongest. Ice troubles are not uncommon and create a problem, the attempt to solve which has sometimes proved too great for the designer. The purpose of this paper is to present for consideration a design of pipe which has recently been offered for intake lines and which has received favorable comment, including its acceptance for the use of two New England cities; in communities whose conservatism in engineering structures is notable.

To resist earth pressures and to withstand emptiness, whether accidental or predetermined, are first requirements. It has been the unfortunate experience of some communities to find their intake first blocked with ice and then flattened by reason of the water pressure against which it was not designed to remain circular. Earth pressures are also quite considerable on such lines near the shore and at the approach to the pump station. It is essential that the pipe shall withstand this pressure as a railway culvert or other such structure would.

The velocity of water flowing in the line should be low, not to keep the frictional resistance low, but to reduce the probability of the indraft of ice and of other floating material.

It is usually the case that it is not practical to make the floor of the trench under water as uniform to grade as is the case with land

¹Abstract of paper read before Canadian Section meeting. Complete article in Canadian Engineer, April 8, 1924.

²Sullivan, Kipp & Chace, Ltd., Winnipeg, Man.

trenches. It is necessary, therefore, that the intake pipe should be provided with such joint equipment that it will be easy to assemble and to caulk the line in such manner as to be able to depend on it to deliver only that water which has been received at the mouth or intake proper. It is less necessary that the line may be flexible in a horizontal direction, because it is easy to adjust the trench alignment without disturbing the foundation of the line.

Contraction joints are as necessary under water as on land. Many men claim that they are not an essential of pipe lines for certain water carrying purposes, but a little consideration will convince the thinker that it is from the temperature changes in the water itself that the shrinkage and the expansion of length are usually derived.

An intake line will float when emptied unless it is heavy enough of itself or is weighted down sufficiently to equal the flotation or buoyancy effect of the water in which it is submerged. This is true whether the line be backfilled or not.

Water works authorities do not like to expend, out of sight, a large proportion of their investment, and it is desirable that the resources of the system should be utilized to give service to the maximum number and dimension of demand. An intake pipe line should be of such material and such class of construction as to meet this requirement in the sense of the highest economy.

That class of pipe line is most suited for intake purposes that offers to the formation of ice or to the adhesion of ice the highest heat insulation, as an intake is frequently called upon to deliver water bearing a quantity of ice; under such circumstances it is necessary that the ice may not be encouraged to adhere to the wall of the line and so greatly reduce its capacity at the very time that the maximum capacity is required.

The author speaks for reinforced concrete pipe precast and fitted in each length with contraction joints for caulking from the inside as that design which most nearly fills all the ideal requirements mentioned above. It is of permanent character, is strong, flexible, heavy, of high capacity on account of smooth interior surface, economical and discourages formation or adhesion of ice. As a second choice a similar design of pipe cast in place, as is somewhere possible, is recommended. There is another advantage of these classes of construction in the use of local labor and material. Therefore, the local spending of the public monies of the community are at a maximum.

The development of the use of reinforced concrete pipe for water supply and intake lines has been of recent date and the corporations

that have claimed the writer's efforts during the past three years have been the pioneers in America, having applied a great deal of energy, thought, courage and capital in the work. They have developed three different "expansion joints" (as they are erroneously called), and each has a proper utilization in the industry. The first was of copper ribbon beaded, in combination with a mortar filled joint space; the second is a combination of fiber-filled lead gasket with cast iron bell and spigot, each properly machined; the third, and that which is now offered for use in intake lines, is a combination of fiber-filled (and therefore elastic) lead gasket, with rolled steel bell and rolled steel spigot of special section.

It is suitable for all pressures as well as for intake lines; it may be used in all diameters larger than 30 inches or for such lines as a man may enter and within which he may use his caulking tools. For use, or rather for laying under water, it is equipped in each length with a pair of pulling up bolts, on one axis, approximately the horizontal axis; these bolts pass through two eye-bolts set into nipples cast in the wall of the pipe. The spigot of the pipe being laid is entered into the bell of the one in place; it may slip home without effort, but otherwise a very slight strain on the pulling bolts is sufficient to bring the spigot close into the bell. As each pipe length is placed the joint is caulked from within; this is not much more of a task than the making up of the joint in open trench would be; divers have assured the author that they can caulk two such joints under water in the time that would be required for caulking three in open trench. After caulking, the caulking space inside the pipe is filled with a "sausage" of dry mortar, which is temporarily supported in position by means of short wires which project from the end of the spigot of the pipe.

This pipe is manufactured in lengths of 12 feet. While it is desirable that it be made available for all communities, it is only possible to furnish it where the dimension of the job, either the intake itself or in combination with other lines in the system, make a contract of sufficient value to warrant the setting up locally of the manufacturing plant, which itself must be shipped to the site from headquarters. This is often the condition obtaining. It would be the case for instance in the new Hamilton supply and intake project, which in all would make an attractive contract; even the intake itself would be of considerable value. In the neighborhood of the yards of the company it would be practicable to ship the pipe needed; this was done for two towns in New England this past year.

CUTTING LARGE SIZE CAST IRON PIPE¹

BY W. M. RAPP²

The writer has for years had quite an extensive experience with repairs and construction on large size cast iron mains.

The following is a description of a cut I have had in mind for years, but not until recently has the equipment been available for the experiment. The method pursued was as follows: 48 inch class "B" pipe was placed in position for cutting. A Mueller dry tapping machine and chain were placed around the pipe (the "body goose neck" having been lengthened to accommodate an air drill). A "Little Giant"—Class G—air drill (made by Chicago Pneumatic Tool Co.) was placed on pipe under tapping machine. A Morse twist drill was used, 1 inch in diameter. This air drill was operated by an Ingersoll-Rand air compressor.

The time to change the machine and to drill thirteen 1-inch holes was fifty minutes. After these holes were drilled, a diamond point cut was made between and connecting the 1-inch holes around the circumference of the pipe. Time required was one hour and thirty minutes.

Eight 1-inch, tapered steel gads were next placed in holes around the pipe as shown in figure 1. As stated before, there were 13 holes drilled in the pipe, but gads were required in only 8 of these holes to break the pipe as desired. Time of driving up these steel gads until pipe parted—four minutes. Result, a cut as smooth and true as if cut by a machine.

In the first experiment tried out we used a $\frac{5}{8}$ -inch round, tapered steel gad 5 inches long, $\frac{1}{2}$ -inch taper to the foot. This was not satisfactory, however, as it was too small for the heavy hammers and caused a rough uneven break. The next size tried was 1 inch round, 6 inches long, $\frac{3}{8}$ -inch taper to the foot; this size was suitable for heavy hammers, but the break in pipe was still rough and uneven.

¹Presented before the New York Section meeting, May, 1924.

²Department of Construction and Distribution, Water Works, Atlanta, Georgia.

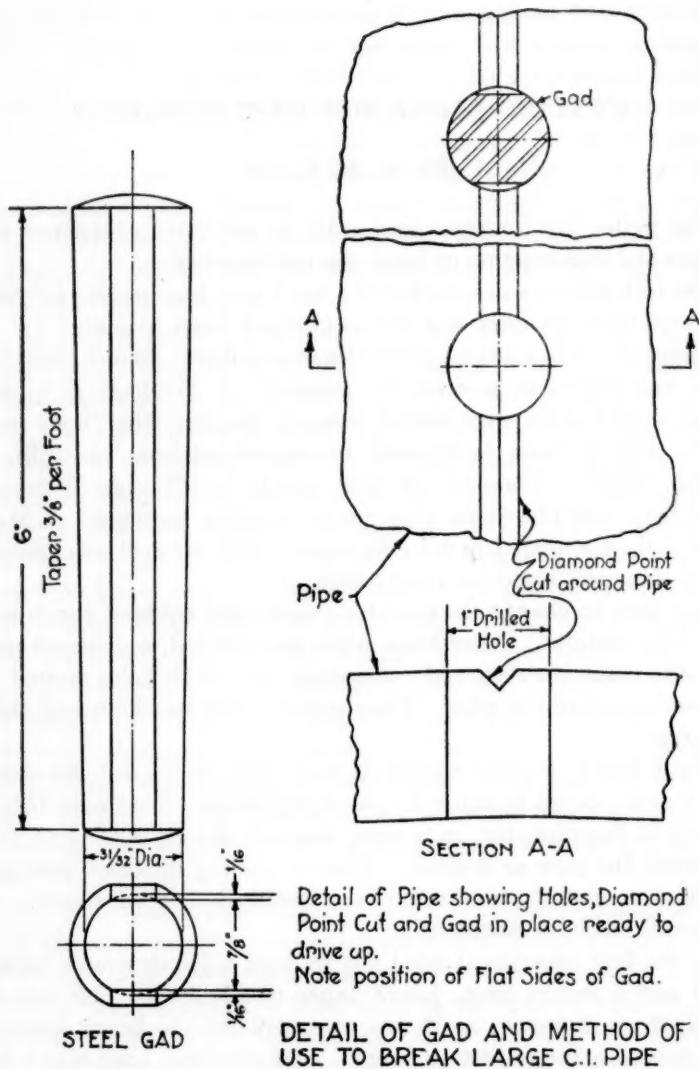


FIG. 1

We then planed two sides of these gads slightly flat and placed the flat sides next to the diamond point cut. This gave the desired result, a smooth even cut. A study of the figure of this gad will explain the method.

I am waiting the first opportunity to try the above described method on pipe in the line (in the ground).

If you are familiar with cutting 36- or 48-inch class "C" and "D" pipe in the line for repairs, etc. and if results obtained by using the foregoing method are half as satisfactory as the cut described, you may imagine what this will mean in the saving of time and money.

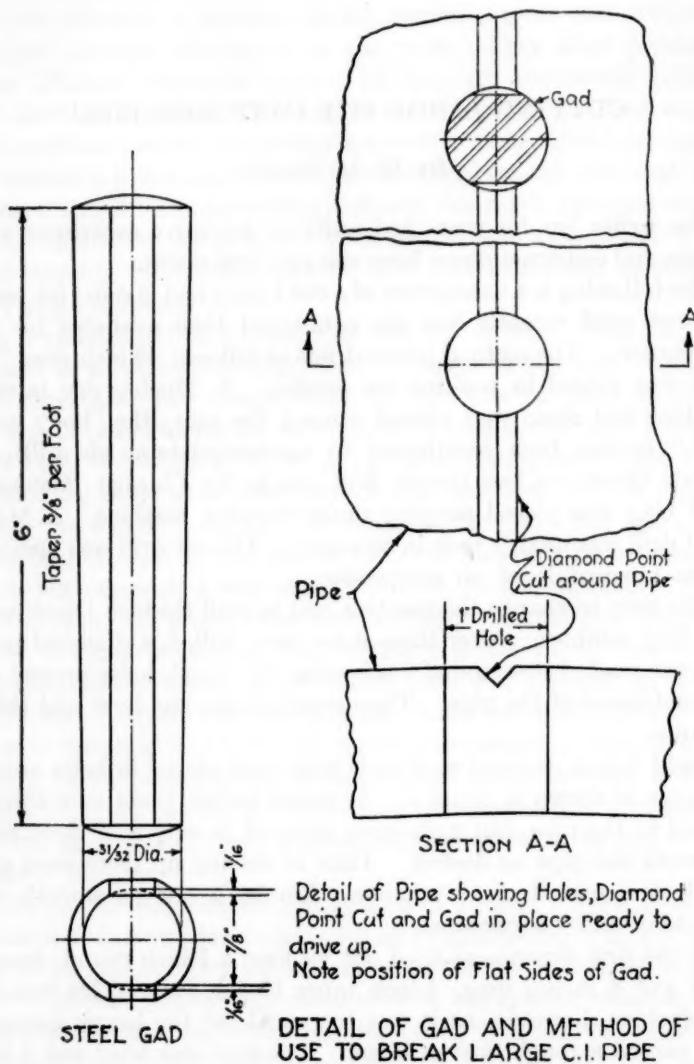


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PLUMBING FOR HIGH BUILDINGS¹

BY GEORGE READ²

A congested section of large buildings in the City of Los Angeles covering an area of 345 acres consumed by meter measurement through 967 meters in the month of September 1923 a total of 30,557,200 cubic feet of water. This amount of water is equal to 589 miners inches steady flow for thirty days at a twenty-four-hour day or 1178 miners inches for a twelve-hour day. A miners inch was computed at 9 gallons per minute. The source of supply for this district is from three reservoirs at an average elevation of 444 feet above sea level. The total capacity of these reservoirs is 843,807,458 gallons. These reservoirs are the source of supply for a great deal more territory outside of the congested section referred to. The average elevation above sea level covering most of this congested section is 261 feet. The difference between the average reservoir elevation and the average street level in this congested section is 183 feet which is the average reservoir static head.

The main pressure was taken from six fire plugs in this district by recording gages for twenty-four hours and showed a mean pressure of 67.5 pounds per square inch. From 6:00 a.m. to 6:00 p.m. the mean pressure was 62.25 pounds per square inch and during this time 47 pounds was the *lowest* recorded. From 6:00 p.m. to 6:00 a.m. the mean pressure was 72.75 pounds per square inch and during this time 83 pounds was the *highest* pressure recorded.

Note: This 83 pounds, the highest pressure recorded, is 4.3 pounds per square inch more than the average static reservoir head, which is due to one reservoir being 4 feet higher than the average, and also the location of one fire plug was 22 feet below the average street level. The pressure recorded shows conclusively that the bulk of water consumed is between 6:00 a.m. and 6:00 p.m. or a 12-hour day.

We have a building ordinance covering this district prohibiting the erection of buildings over 150 feet, but storage tanks for water

¹ Presented before the California Section meeting, October 25, 1923.

² Superintendent Meters and Services, Bureau of Water Works and Supply, Los Angeles, Calif.

supply may be 22 feet above this height. As it requires a main pressure of 64.5 pounds to reach this height of 150 feet, it may readily be seen that the top floors of a building cannot be adequately served from a distributing system carrying a mean pressure of 67.5 pounds per square inch. There are bound to be times when the consumption on the lower floors will lower the water in the riser leading to the top of the building, especially if the service and meter are too small, which is often the case. The main pressure also is subject to fluctuation. A riser with no laterals 150 feet high being fed from a main pressure steadily maintained at 67.5 pounds per square inch would only have a pressure of 3 pounds per square inch left for discharge. In many cases complaints of poor supply are due to the service and meter being too small to meet the high peak of consumption, and still maintain a head in the plumbing. There are cases where the service and meter are large enough, but the plumbing in the building is inadequate. In either case the Department is blamed for giving poor service. Good supply for all buildings that are not too high to be served at all times from the distributing system depends upon the size of the service and meter and the plumbing system in the building.

A water connection leading into a building and feeding its laterals has the same function to perform as a street main has in feeding its service connections. If the main pressure is poor or inadequate in size to feed its connections the service is poor.

If the service connections are too small to maintain a head on the plumbing while feeding their laterals the service will be poor, even if the main is adequate in every way. The Department always advises the consumer to order a service that will be amply large enough for the present and future needs, but this advice is often ignored, and in a short while the consumer is back requesting to have the service enlarged.

Buildings that are too high to be adequately served from the distributing system should have a service and meter large enough to meet the high peak of consumption on the lower floors and still maintain a head in the plumbing to serve as high as may safely be served from the main pressure. All stories above this should be served by pumping with a smooth running pump to a tank of liberal dimensions placed on the roof. This tank should be placed high enough above the roof to give sufficient head for toilet flushing, etc.



FIG. 1

A liberal sized pipe with no laterals off of it should run directly from the pump in the basement to the tank on the roof. This line should be equipped with a check valve on the discharge side of the pump. From the bottom of the tank a liberal sized pipe should run to the basement and be connected with the piping leading in from the service.

This connection should be made between the pump and the meter, so as to have direct street main pressure. On this line coming from the bottom of the tank a good wheel valve should be placed and closed to control the upper floors to be supplied from the tank, and the lower floors to be supplied from the street main. An additional valve should be placed on this line coming from the bottom of the tank, one or two floors below the division valve and left opened. In case the main pressure should fall off for any reason this valve may be closed and the division valve opened, allowing the water from the tank to feed that much lower or the whole building may be temporarily fed from the tank. A check valve should be placed on this line at the basement to prevent the water from flowing back to the pump, in case the valves controlling the upper and lower floors are opened. A check valve should be placed on the main line leading in from the meter to prevent any water flowing back from the pump to the street main.

There are buildings being entirely supplied from tanks on the roofs which are fed directly from the street main. During the day-time due to fluctuation in the main pressure when the consumption is the heaviest there are times when the water will not reach these tanks, but it will always flow into them during the night time.

If the main pressure remains too low to feed these tanks for any length of time and the storage tanks are small in capacity, the whole building goes dry. I personally have seen cases where a building was out of water due to the storage tank being empty, and at the same time water was standing in the pipe supplying the tank half way up its side, and have suggested to the building engineer that he tap the bottom of the tank, instead of going over the top and have been told that that would never do, because the incoming water would have to lift all the water in the tank.

A building under these conditions may adequately be served the same as outlined for covering buildings where the water has to be pumped to supply the upper floors. The only difference would be that the water would fill the tanks in the night by main pressure

instead of having to be pumped. The tank could then supply the upper floors only during the day. High buildings may be served by running a line to a tank and also supply the building through the same line. This may be done by entering the tank through the bottom at two places, one connection to be equipped with an automatic shut off, inside of the tank to control its filling, and the other connection to be equipped with a check valve on the outside of tank allowing the water to flow only from the tank back into the line which feeds it. A check valve could then be placed to control the floors to be fed from the tank.

HYDROGEN ION CONCENTRATION AND WATER PURIFICATION AT CEDAR RAPIDS, IOWA¹

By F. C. MORTENSEN²

With the advent of the more recent conceptions of the nature of the colloid and its behaviors, there have come numerous applications of the new knowledge to the needs of man. Not among the least of these is its application to the artificial purification of water.

Rain water, as it falls upon the ground, is comparatively pure, but as it comes into intimate contact with the earth crust, it becomes polluted, receiving into solution the soluble matter and into suspension some of the smaller particles of the insoluble matter.

As the water filters through the soil, it is freed from the suspended matter, but more and more of the soluble matter is picked up, until at a considerable depth, where the water collects in underground channels, the sources of wells and springs, it is clear but hard.

The water that is drained off into streams does not go through this process of filtration and therefore carries with it its load of suspension, as turbidity and color and soluble matter.

In places where the demand for water clear and "pure" is great, and the naturally filtered water is not present in adequate quantities, or is difficult to obtain, it is necessary to resort to artificial methods of purification. This is done by duplicating as far as possible the processes of nature, but with such auxiliary treatment as the ingenuity of man is able to devise, to make it at once perfect and practical.

THE COLLOID IN SURFACE WATER

The suspended matter in the water naturally tends to settle out, and as soon as agitation ceases, the larger particles are let down, the water retaining in suspension only the smaller, very finely divided particles of color, turbidity and bacteria. These very small particles are thought to range in size from the barely visible to the infinitesimal, approaching the size of the molecule as a limit. These small

¹ Presented before the Iowa Section meeting, October 25, 1923.

² Professor of Chemistry, Coe College, Cedar Rapids, Iowa.

particles are called colloids and have the property of carrying charges of electricity (1) some positive and some negative. This charge carried by a colloid is readily determined by its action under the influence of an electric current. Oppositely charged colloids (2) neutralize each other and collect into masses large enough to settle rapidly and to be retained by a properly constructed filter. To treat water in such a way as to precipitate all the undesirable colloids is the problem of the water works.

BACTERIA ARE COLLOIDAL

In no field is colloidal chemistry of so much importance as in that of water sanitation (3). This involves a study of the smallest living individuals, bacteria. Bacterial cells suspended in water or in water solutions are colloids. They migrate under the influence of the electric current toward the anode and are therefore negatively charged. They are precipitated by positively (4) charged ions such as hydrogen, sodium and calcium and are much more sensitive to heavy metals and especially aluminum and ferric ions (5).

Natural waters may contain other colloids besides bacteria. Water from swampy regions is usually colored (6) largely with organic colloidal material, with some in true solution. These particles are positive in charge, except in highly alkaline waters when they are negative.

The water from our Iowa streams and rivers are more or less loaded with clay or silt which in the finely divided state causes turbidity. These particles are similar in charge to that on the bacteria so that any method which removes turbidity will at the same time be effective for the removal of bacteria. Catlett (7) in his study of water purification at Wilmington, N. C., noted that a mixture of turbid water from the Cape Fear River and the highly colored water from the Northeast River would clarify if given sufficient time. By the proper adjustment of the acidity and alkalinity he was able to reduce the purification cost from 50 to 70 per cent and to give a water which was not corrosive.

THE REMOVAL OF COLLOIDS

Work was begun at the Cedar Rapids plant in the summer of 1921 under the direction of Mr. Jack J. Hinman, Jr., of the State Board of Health at Iowa City, to determine if, by proper control of coagulation, sedimentation, filtration and chlorination, a better quality of water could be produced at less expense.

A small settling basin was built which has proven its worth. The short time given for coagulation and sedimentation has increased the efficiency of the filters and improved the quality of the water. The basin was first used on February 2, 1922, consequent upon a succession of heavy rains which brought from Cedar Lake the highly colored water into the river. The usual method of treatment of dosing with alum in excess, with a moderate amount of lime, served only to make matters worse, in that the color was "set" with the production of a milky effluent. The residual aluminum compounds in the water effluent gave us many complaints as to taste and, since then, as to the corrosive effects on the plumbing. Laboratory tests showed that the water became more highly colored as it passed through the basin, due, of course, to the solution of the tannates and gallates from the new timber of the basin. Tests also showed that, if the bicarbonate alkalinity could be lessened, better results could be obtained. We then began to decrease the alkalinity and found that the water must be acid. The exact acidity we found to vary, but a hydrogen ion concentration of 5.6 gave results. With the passage of the colored water the proper pH for the water in the settling basin was found to be about 6.5. This is in agreement with Longley's findings that for the removal of color the alkalinity should be low. During this period of colored water, the river water was almost free from bacteria due to the mutual precipitation of the positively charged color and the negatively charged bacteria.

A few weeks after the above mentioned colored water had passed the ice in the river broke up with an increase of turbidity. Eight grains of alum per gallon were added to a water with a turbidity of 700 p.p.m. and an initial pH of 6.6. Precipitation was effected and settlement was rapid, leaving the water clear and with a final pH of 6.0.

THE ISOELECTRIC POINT

It seemed important therefore that the proper charge be kept on the alum to bring about the effective removal of color or turbidity. For the removal of color the alum must be negative, while positive for the removal of turbidity. It has been generally held that alkalinity is the factor which governs the precipitation of the alum, but certain experiments indicate that there is an optimum point at which all of the aluminum hydroxide is precipitated, and that above this

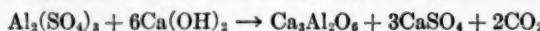
point on the alkaline side and below it on the side of acidity the precipitation is not complete. The reaction (8)



or



is so simple that it has become generally held that if the coagulum $\text{Al}(\text{OH})_3$ is not instantly and continually formed the treatment is either careless or faulty. Ineffective floc formation and residual aluminum hydroxide in filter effluents, even with plenty of raw water alkalinity, are probably due to other causes than poor control. Two explanations are proposed for the resolution of the aluminum hydroxide, one that it is due to variations in the chemical combination (9), the other that resolution is due to peptisation (10). There is experimental evidence for both explanations and it is clear that the presence of hydrogen or hydroxyl ions gives us a basis on which to predict whether or not a change will take place. In the case of amphoteric (11) hydroxides, such as aluminum hydroxide, an excess of alkali is to be avoided. It becomes desirable, therefore, to select that degree of alkalinity which will insure most complete precipitation and at the same time avoid resolution of the precipitate. Blum states that the precipitation of aluminum hydroxide begins at a pH of 3 and is complete before a pH of 7 is reached in the action of sodium hydroxide on aluminum chloride. He finds that from a pH of 7 to a pH of 10.5 resolution of aluminum hydroxide in sodium hydroxide is increasing in action until at the latter point the solution is almost complete.



To determine the isoelectric point of aluminum hydroxide in various alkaline solutions 10 mgm. of aluminum sulphate were added to a liter of distilled water in an Imhoff cone. The alkalies, sodium hydroxide, sodium carbonate, sodium bicarbonate and lime water were prepared containing 10 p.p.m. of available alkali. The alkali was added in 0.5 cc. portions, stirred well and allowed to stand exposed to the carbon dioxide of the laboratory to settle for three hours. The amount of aluminum hydroxide precipitated was read in cubic centimeter and plotted against the pH at that time. The

pH was determined by the colorimetric method outlined by Clark and Lubs. Solutions were prepared as directed and checked against solutions made according to the direction of Sorensen.

In all cases the precipitation began at a pH of 3.0 and resolution was complete at a pH of 10.5. Precipitation and resolution was most rapid for the lime. Precipitation was complete for the lime at a pH of 6.6, sodium hydroxide at 6.8 and for sodium carbonate and bicarbonate at 7.4. While these results indicate that the isoelectric point is near 7.0, it would appear that the difference in results is due to the effect of the ions. Some work was done as to the influence of various salts on the precipitation value of aluminum hydroxide and the results indicate, as did the work of Smith (13) on silicic acid and Weiser and Middleton (13) on the precipitation values of potassium salts on hydrous alumina oxide, that each ion of the salt as well as the salt itself influence the pH and, therefore, the precipitation value. The raw water during the greater part of the year has a pH of 7.0 and after alum treatment is between 6.6 and 6.8. This clears well in the settling basin. The water coming through the filters has a pH of 7.0. When the pH of the water in the clear well was kept at 7.0 or lower before chlorination better results were noted in bacterial removal. This Rideal and Evans explain is due to the fact that acid waters have a higher oxidizing power than do alkaline waters.

It has been our experience that, following the breaking up of the ice and the heavy April, June and October rains, as soon as the hardness drops below 100 p.p.m. the corrosive property of the water increases noticeably. At such times the addition of lime after filtration to the clear well has decreased this source of complaint.

The determination of the hydrogen ion concentration of our water has given us a more satisfactory method of control than the alkalinity titration method, in that we know the pH which will give the best floc formation in our settling basin, the most complete residual aluminum hydroxide removal by our filters and the greatest oxidizing power of the chlorine.

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BILLING AND COLLECTION METHODS¹

BY E. R. PRENTICE²

The first duty of a water company is to supply water, and the second duty is to charge and collect for that service.

The billing and collection methods of all companies are, of course, similar in many respects, but in detail it is probable that no two companies use methods exactly alike.

The first system with which I came in contact was most ideal from the viewpoint of the water company. This was in the early days of one of Nevada's prosperous mining communities and water was delivered to consumers in tank wagons. The only bill in connection with the transaction was a "green-back," and collections were made at the time and place of delivery. The only way to beat the water company there was to carry water for yourself from a spring that was located in the hills just outside the town. There was no real economy in doing that, however, as the trail to the spring led past the brewery.

In our district we render monthly bills for water service, billing approximately 350 consumers each day, making a total of about 8750 bills per month. All bills are made in duplicate using carbon paper which is inserted between the two parts of the blank bill-form before the billing operations begin. The bill is then put through the addressograph machine, which prints thereon, the name and post office address of the consumer; the service number and ledger reference; and the date showing the period of time covered by the bill. After this operation is completed the bill goes to the billing machine which is a Remington typewriter equipped with a wide carriage and Wahl Adding Machine attachment. This machine types in the readings, consumption, charge, past due balance and total amount due. The charge, past due balance and total amount due are also typed on the cash stub which is attached to, and made a part of, the bill as it goes out to the consumer. The perform-

¹ Presented before the California Section meeting, October 24, 1924.

² Secretary, Marin Municipal Water District, San Rafael, California.

ance of this operation requires ten totalizers and six totals are carried in the machine to the end of the billing of each route. These totals are then compared with the totals arrived at by the ledger clerk who has figured the same bills in the consumer's ledger, and if the two totals are the same, the computations are assumed to be correct. Then after the removal of the carbon papers, and the separation of the carbon copy from the original, the bill is ready to be mailed to the consumer. All carbon copies are retained for office use and the original is placed in a window envelope; sealed and sent to the post office.

We use only stamped envelopes purchased from the post office department as we have found them to be the cheapest and the most satisfactory. The window envelope is used to save the labor of addressing envelopes, as well as to avoid the possibility of errors in addressing them.

As we have no collectors, all bills are sent to the consumers by mail.

Payments on water bills are made by mail, by cash at the counter and through the banks located in the several towns throughout the District. The payments received by mail averaged 51 per cent of the total number of payments. Those made at the counter average 22 per cent and collections made through the banks represent about 27 per cent. This percentage is based on the total number of payments made and not on the amount of money received.

We have an arrangement with all of the banks of the District, whereby they accept payment of water bills and credit the amount so received to our "collection account." They do not take any work orders of any nature whatsoever, nor do they attempt to adjust any claim, settle a controversy, or hear a complaint. They merely accept a payment for the District when that payment is in full and is accompanied by the cash stub of the bill that it is intended to cover. For this service the bank receives no direct compensation from either the District or the consumer, but they appear to be quite willing to render the service in return for whatever business it may indirectly bring to them.

A property owner's guarantee, or a service deposit of \$5.00, is required of all renters who have not established their credit with the District, but no deposit is required of a property owner unless our previous experience with him has shown us that his bills will not be paid within a reasonable time.

If a consumer owes for more than two month's service we send him a notice stating that the service will be discontinued if the account is not paid in full within five days. Some consumers will not pay until the water is actually shut off. Of course, it is impossible to escape all loss from bad bills and a consumer sometimes leaves the District owing us a water bill, but the natural beauty of Marin County, its delightful climate, its pure water and its general prosperity all combine to call the wanderer back, and sooner or later he again lights within the boundaries of the Water District and makes application for service. Then he pays the old bill and puts up a service deposit before he gets the water. It sometimes happens that bills of several years standing are collected in this manner.

The labor cost of our billing and collection department is at the present time about 7.5 per cent of the total cost of operation and covers the salaries of seven employees, namely, one ledger clerk, one billing clerk, one addressograph operator, one order clerk, one cashier and two meter readers. The entire time of these seven employees is not given to billing and collection work, but that work takes up the principal part of their time and the balance is taken up by other general office work.

There is, undoubtedly, a considerable benefit to be obtained by having regular collectors call on the consumers each month, but in our District, up to the present time at least, we have found that the expense in connection with this work would be quite out of proportion to the benefit that we would derive from it, as our percentage of loss through bad accounts during the past eight years has been very low indeed. When occasion arises that we find it absolutely necessary to send out a collector, we impose that duty upon the inspector or one of the clerks from the office.

The Marin Municipal Water District has been a decided success as is shown by the monthly financial reports that are put out under the supervision of Mr. John F. Forbes, who is at the head of the Pacific Coast Department of Haskins and Sells, a firm of certified public accountants, internationally known. We believe that the methods we are now using in our billing and collection department have been instrumental in building up this success, because they have brought in almost every dollar of revenue that has been earned by the District.

However, as time goes on and the water consumers of Marin County increase from 8000 to 80,000 we will probably find it necessary to change our methods from time to time to take care of the increased business.

COLLECTION OF COSTS FOR EXTERNAL DAMAGES TO WATER SYSTEM¹

BY O. E. CLEMENS²

The water company with the proper public relations viewpoint willingly accepts responsibility and makes restitution for damages to the property of citizens. The citizens in turn should pay for damages caused by their own acts to the property of the Water Company.

Happily, Spring Valley Water Company has relatively few cases of the latter. When responsibility has been definitely fixed, collection of the costs are invariably made without trouble. These matters are the least of our worries.

I shall briefly review the cases in order of their frequency of occurrence.

BROKEN AND STOLEN STOP-COCK LOCKS

Lock-wing stop cocks are now installed by us on all small services. When a contractor orders a series of services to be installed for a group of residences he usually accepts responsibility for water service through two or three, depending on the number of buildings, the remainder being locked by the service crew when the service and meter are set. This is a necessary precaution.

Before we put this system into effect we lost a considerable quantity of water—likewise revenue—through the unwarranted and unauthorized use of these services. Occasionally one of the sub-contractors, usually the plumber, wants water and breaks the lock. As a rule we are able to fix responsibility and collect for the damaged or stolen lock.

It is not the amount of money involved so much as the deterrent effect. Prior to the general installation of meters, and when the flat rate system of billing was in effect, contractors were allowed to use water from any source obtainable—usually from the house adja-

¹ Presented before the California Section meeting, October 24, 1924.

² Manager of Water Sales, Spring Valley Water Co., San Francisco, Calif.

cent. We then billed on a flat rate basis for the water used—after the several contractors had been located and responsibility fixed. After many years of this somewhat loose system it has been something of a problem to educate some of the contractors, in particular the more or less irresponsible element, to make proper application before using water.

LOST OR DAMAGED METERS

For street work meters are usually installed on hydrants. Although the contractor pays the net cost of installation he gains an advantage in rates. The flat rates are obviously enough higher to cover waste of water and special inspection expense.

On such installations the contractor is responsible for the meter and pays the damage if lost or damaged.

At the water front we have many vessels taking water at more than one dock—for example, a tramp schooner unloading or taking on cargo at two or more docks. She takes on water while at work, a meter being loaned for measuring. Sometimes the meter goes overboard or is carried away and lost by the vessel. In such cases we recover the cost, although sometimes it is six months or a year later when the check comes in from some foreign port.

SERVICES BROKEN BY GRADING CONTRACTORS

In such cases no claim is made by us as such breaks are usually unavoidable in the re-grading of streets.

BREAKING OF MAINS

Sometimes a main is broken when the retaining wall of a building excavation gives way. The contractor in such cases reimburses for the damage done.

HOT WATER DAMAGE

Damage to the meter disks by hot water escaping into the service from an overheated hot water tank is sometimes caused. We have made no claims on this account owing to the difficulty of establishing definite responsibility and the minor expense involved.

We recently had an interesting case where a considerable expense was involved. At a new building complaint was made that we were

serving them with hot water—this not being in accordance with the understanding. Upon investigation we found the local heating company had installed their steam lines along our main. As we were there first, they, of course, had to stand the expense of relaying our lines. Ours were changed, as they were smaller and the expense less.

BROKEN FIRE HYDRANTS

As the fire hydrants belong to the City, damages to them are collected by the Fire Department, which makes the repairs. However, if the service pipe is broken, requiring work by our distribution department, we bill and collect from the aggressor.

MALICIOUS DAMAGE

Although we had some trouble in certain sections of the City following the inauguration of general meter rates in the fall of 1918, we did not attempt to collect damages where meter dials were found smashed or the bronze caps removed. We considered this part of the expense of our general program in the education of the public to the appreciation of meters as against the former unfair "flat rate" system.

We are glad to say that cases of malicious damage are now very, very few and far between.

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METHODS OF DEVELOPING UNDERGROUND WATER SUPPLIES¹

By E. W. BENNISON²

The successful development of underground water for domestic and industrial supply is a problem which has engaged the attention of water supply officials and engineers for a good many years with varying degrees of success. Involving, as it does, some knowledge of several closely related sciences, it has only been in the last few years that special attention has been paid to the problem with the idea of using such information as is available in order to avoid previous mistakes and prevent further waste of money.

We will pass the questions connected with the occurrence of water in the earth's crust, together with the questions concerning the amount and rate of flow, quality, etc., to the question of a development of an underground supply, assuming that one is present.

The first problem is to investigate such questions as the rate and direction of flow, and quantity available in the water bearing beds, the danger of contamination, the nature of the beds to avoid localized supplies, the character of the material in the beds for their ability to deliver water, the action of the water when tapped, together with its static head, temperature, etc., keeping in mind the demands that will be made later on the supply by the users. If it is found from these preliminary studies that it is feasible to go ahead with the development then the question of how to obtain the water presents itself.

By far the most common method of making an underground supply available for use is to sink one or more wells into the water bearing formation. There are other means such as collecting systems, infiltration galleries, impounding flowing springs, but these are special problems and are treated as such. The general use of wells, however, gives opportunity for the most study and also the most improvement in them as a means of obtaining underground water. Before undertaking to develop a well supply a report

¹ Presented before the Iowa Section meeting, November 7, 1924.

² Engineer, Kelly Well Co., Grand Island, Nebraska.

of the general geologic conditions, together with a study of the existing wells in a locality, is generally sufficient to determine the type of well construction best adapted to the situation. By type, the well builder refers to two general classes into which all wells are divided, namely, shallow or deep wells. Each have their advantages which should be carefully compared. The practice at present favors the small diameter cased well as it is known that in the final analysis no more water can be obtained from a well than the water bearing sands are able to pass up to it, provided the well is constructed in such a manner as to allow 100 per cent of the water to enter the well.

Shallow wells are of two kinds, large diameter or open wells and small diameter or cased wells. In some localities wells of both types can be obtained, but generally the cost of deep well work makes the shallow well more economical and unless it is a case of necessity a shallow well usually is the best investment as well as the best water producer. It should be kept in mind that the waters nearest the surface are the softest and of lower temperature than deep waters.

The type of well being determined, the next questions deal with the method of construction, location, size or diameter and the probable yield to be obtained from the wells. Wells are sometimes classed according to the method of construction into dug, bored, drilled or driven wells. To the average person it would not seem that the method of sinking had any bearing on the capacity of the finished well, however, it is a well established fact that the method of sinking does play an important part in the future performance of a well. Recent experiments show that in stratified formations of clay, quick sand, sand and gravel, the greatest supply is obtained when the ground formations are least disturbed during well building. It is also important that an accurate record be kept showing the depth and kind of water bearing formations together with the head and quality of water in each water bearing layer.

Any kind of a well must be provided with openings in the casing through which the water may pass into the well. The size and kind of these openings must be such that they will allow the maximum amount of water to pass into the well with the least effort and without clogging, stopping up or weakening the screen and without passing particles of fine sand into the well which later on either fill it up or are pumped into the system, damaging pump parts and stopping meters. Great care must be used in placing the screens in a well to insure

that they are placed opposite the best water bearing formations. It is a recognized fact that practically all well troubles are screen troubles. The casing of the well also plays an important part and should be just as carefully installed as any other part of the well, special care being taken to see that it is intact when completed and plumb. It should be examined from time to time to insure that it is keeping out undesirable water and is not deteriorating.

The proper location of the well is perhaps as important as any other item, but is the one most often neglected. It has long been the custom to sink a well at some spot previously selected on account of being near a good well or for most any reason except the most important one, namely, that it is in the best formation available. More than once complete water systems have been designed with the source of supply located convenient to the pumping plant and the pumping plant convenient to the railroad. However, it is becoming the practice to give more attention to the proper location of the source of supply.

If it is not known where the best beds of water bearing material are, then some preliminary test holes, if put down properly, will give sufficient information as to the underground conditions to locate properly the new wells. If deep wells are to be put down the geologist's report is about the only information available and often deep holes have to be abandoned when several hundred feet deep for lack of water. This can be prevented in wells of the shallow type. In putting down test holes the old style hydraulic method is not the best as the materials penetrated are washed out of the hole and become so badly mixed up that the samples when analyzed are not a true sample of the underground conditions. This is especially true of holes in sand and gravel, the coarser material separating from the finer which is washed out and lost. The percentage of fine particles being the determining factor in a formation as to its ability to transmit water, it is essential the samples be taken out as they exist in the ground and the thickness of each layer determined accurately. After comparing the results of several test holes it is not unusual to be able to pick a well location in which one well will furnish several times the amount of water that could be obtained from three or four wells put down "hit or miss." Accurate testing not only insures the well in the right location, but gives sufficient information to predict the amount of water a well will yield with reasonable accuracy.

The yields of wells follow certain general principles which you might say are fundamental. Having given a water bearing formation and a well sunk in this formation, the yield when a well is pumped continuously will be proportional to the distance the water is lowered below the normal ground water table. We find by experience that this holds good up to at least two-thirds of the depth of the water in the well before pumping, but that beyond the two-thirds point the draw down increases and the yield decreases. The yield is also proportional to the depth of the water bearing formations and for the same amount of draw down the yield will be larger the larger the diameter of the well, but not in direct proportion. The increase varies as the $\log E$ of R , R being the radius of the screen surface. In other words, in two wells, one 20 feet in diameter and one 2 feet in diameter, all other things being equal the 20 foot one will only give about two times as much water as the smaller one. It will be seen then that the diameter of a shallow well depends largely on the amount of water available and the type pump that will be used on the well. The diameter of deep wells is generally determined by the depth to be penetrated and the exigencies of drilling. In connection with the yield of wells the question of mutual interference should be kept in mind. We all know when water is pumped from a well that the level of the water in the well is lowered and that water flows into the well from the surrounding ground at an increased velocity and that the level of the water in the ground will take the form of a curve. If the well is built in a formation such that the water bearing sands are overlaid by impervious strata then there will be no circle of influence until the static head is removed, but a curve of pressures can be plotted by measuring the decreasing head during pumping which closely follows the curve representing the ground water curve. The shape of this curve depends entirely on the formation and rate of pumping, but it finally reaches a point at some distance from the well where there is no effect on the water table. The area in which the water table is lowered is called the circle of influence and after pumping is increased until the water level in the well can be lowered no farther and water is running into the well as fast as it is pumped out then there will be no further change in the circle of influence. If wells are located too near existing wells and these circles of influence overlap, their capacities will be cut down. In the same way, where more than one well is built at a time they should be spaced far enough apart that they can be pumped at their maximum capacity without affecting each other.

There are a number of methods used to increase the yield of old wells such as cleaning or replacing the screens when possible, introducing gravel into and around the well, back blowing with air, steam or even using dynamite in the case of rock wells to loosen up the surrounding rock and form cavities. Nearly all wells in which the yield is decreasing have to be abandoned sooner or later and it is not good practice spending much money trying to reclaim old wells.

Before any well location is finally decided upon, careful attention should be paid to the sanitary features of the well and the quality of the water to be obtained from it. Almost all surface waters or first waters are more or less contaminated and unreliable as a supply. They should be avoided if possible. Waters found under heavy beds of clay are nearly always good from a sanitary standpoint, but may be poor chemically. Deep waters are also liable to be so highly mineralized as to be unfit for use. Some wells are contaminated by surface water seeping into them due to poor construction or location. Every precaution should be taken to insure a sanitary supply and keep it that way after being obtained.

The whole subject of underground water development is comparatively in its infancy, but the necessity and importance of considering the fundamentals underlying the subject are being more generally realized by water officials and many cities and towns are developing satisfactory underground supplies by applying these fundamentals to their water supply problems.

READJUSTMENT OF PRESENT ORTHOTOLIDIN STANDARDS FOR CHLORINE

BY HENRY F. MUER¹ AND FRANK E. HALE¹

As far as we are aware the present orthotolidin standards have not been checked by other workers than the originators.² With the introduction of a definite excess chlorine by orthotolidin control by the Department of Water Supply of New York City and its extension to several well supplies, trouble was experienced in the case of one very pure well water with the apparent finding of more chlorine in the treated water than the dosage applied. After due consideration to possible errors of pumpage, weight of chlorine delivered, and error of machine it was decided to investigate the standards.

A study of the increments of dichromate in the present standards showed considerable irregularities rather than progressive change. Likewise charting showed irregular lines and not smooth curves. In charts made with the linear units of amounts of chlorine parts per million and logarithmic units of amounts of dichromate, combining into a continuous curve equal-sized blocks of 0.00 to 0.10 and 0.10 to 1.0 p.p.m., kinks were noticeable where the two blocks joined, indicating low values in the region of 0.10 p.p.m. Similarly equal sized blocks of 0.10 to 1.0 p.p.m. and 1 to 10 p.p.m. plotted in a continuous curve showed kinks and low values in the neighborhood of 1 p.p.m. The curves through adjoining blocks should be smoothly continuous. There is a probability also that in the present standards 8.7 cc. of dilute dichromate for 0.08 p.p.m. chlorine standard is a typographical error for 8.2 cc., the error appearing in both the original paper and in Standard Methods. The accompanying charts show the irregularity existing in the present Standards. Table 1 shows the irregular increments (see note to table 1).

¹ Chemists, Mount Prospect Laboratory, Department of Water Supply, Gas and Electricity, New York City, N. Y.

² Ellms and Hauser, Orthotolidin as a reagent for the colorimetric estimation of small quantities of free chlorine. *Jour. Ind. Eng. Chem.*, v, 915, 1030, 1913.

At first the attempt was made to smooth out the increments by inspection and from the curves and then compare the probable accuracy by a process of halving, for example comparing a half of 0.10 p.p.m. standard with 0.05 p.p.m. This worked only approximately and failed of sufficient accuracy, due probably to the fact that there is a varying relation between copper sulphate and dichromate, the former being constant as the latter increases.

It was then decided to make up a chlorine solution of sufficient strength to determine by titration and to check the standards by dilutions of this chlorine solution. The chlorine was generated chemi-

TABLE 1
Irregular increments of present standards

CHLORINE p.p.m.	DILUTE DICHRO- MATE cc.	INCRE- MENT	CHLORINE p.p.m.	STRONG DICHRO- MATE cc.	INCRE- MENT	CHLORINE p.p.m.	STRONG DICHRO- MATE cc.	INCRE- MENT
0.01	0.8	8	0.1	1.0	10	1	7.2	7
0.02	2.1	13	0.2	2.0	10	2	12.0	5
0.03	3.2	9	0.3	3.0	10	3	21.0	9
0.04	4.3	11	0.4	3.8	8	4	30.0	9
0.05	5.5	12	0.5	4.5	7	5	39.0	9
0.06	6.6	11	0.6	5.1	6	6	46.0	7
0.07	7.5	9	0.7	5.8	7	7	56.0	10
0.08	8.7	12	0.8	6.3	5	8	63.0	7
0.09	9.0	3	0.9	6.7	4	9	70.0	7
0.10	10.0	10	1	7.2	5	10	75.0	5

Note: Standard Methods contains values only to 0.50 p.p.m. chlorine and uses a dilute dichromate solution throughout. Throughout this paper the full values of Ellms & Hauser, 0 to 10 p.p.m., are included and the use of their strong dichromate solution, ten times the weak solution. In addition a double strength strong dichromate solution is added in the latter part of the paper for the 1 to 10 p.p.m. standards proposed.

cally in a 2-quart bottle by reaction of hydrochloric acid with potassium chlorate. The gas was decanted or led by glass tubing over the surface of redistilled water in another bottle and the latter shaken occasionally until a solution of approximately 200 p.p.m. available chlorine was obtained. From this solution another of approximately 20 p.p.m. chlorine was made, which kept with little loss in an amber colored bottle for weeks. Its strength was determined by titration with N/100 thiosulphate after reaction with potassium iodide in presence of acetic acid or hydrochloric acid. Blank tests on reagents with orthotolidin were zero.

The first attempts were made to determine the correct value of the standards from the chlorine solution without necessity of dilution. To 10 cc. of a 22 p.p.m. chlorine solution was added 1 cc. of orthotolidin solution. The height of the liquid in a Nessler color tube was measured as 26 mm. The height of this color-developed chlorine solution necessary to match the 1 p.p.m. standard

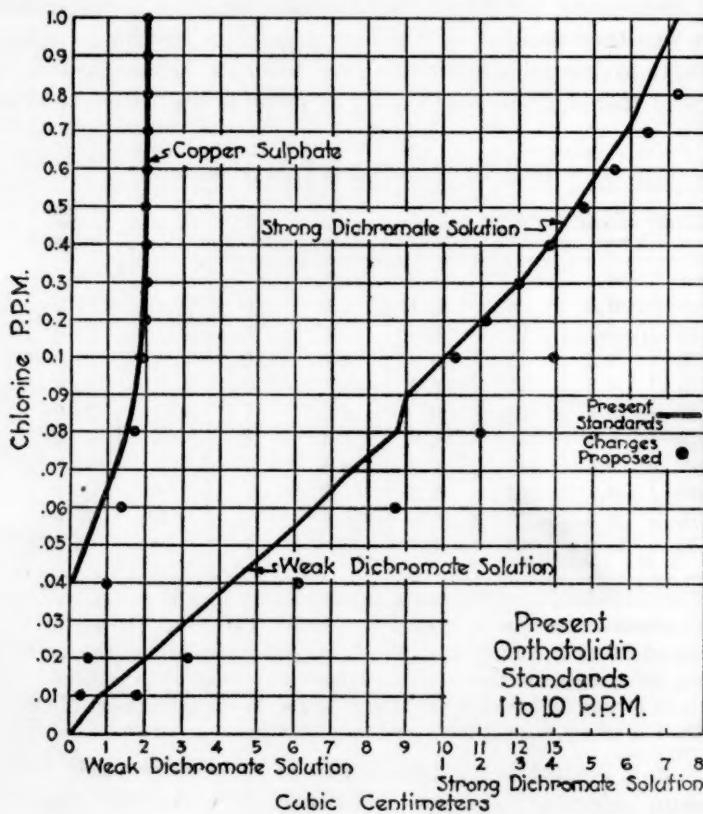


FIG. 1

was then determined to be 10 mm. Now if the 10 cc. of 22 p.p.m. chlorine had been diluted to 100 cc. with due correction for the addition of 1 cc. of orthotolidin in the actual comparison it would represent a chlorine solution of 2 p.p.m. Therefore multiplying 2 p.p.m. by $10/26$ (the ratio of the heights) we obtain 0.77 p.p.m. chlorine. That is the 1 p.p.m. standard is low.

Similarly, to 50 cc. of 22 p.p.m. chlorine solution was added 5 cc. of orthotolidin and fifteen minutes allowed for reaction. The depth was measured and the depth required to match the 1, 5 and 10 p.p.m. standards determined. The results were that the 1 p.p.m. standard equalled 0.76 p.p.m. chlorine, the 5 p.p.m. standard 3.5 and the 10 standard 6.2 p.p.m. All color comparisons were based on the dimensions of the Nessler tube to be such that the 100 cc. mark was 24 cm. high.

Attempt was next made to determine the correct value of each standard from 0 to 1 p.p.m. by measuring the correct amount of chlorine solution into a Nessler tube, diluting to the mark, adding 1 cc. of orthotolidin and allowing fifteen minutes for reaction. The

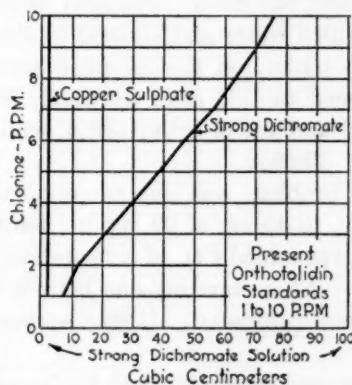


FIG. 2

result was a complete failure, all results being evidently abnormally low, the 0.10 chlorine dilution showing only 0.033 on the standards and 1 p.p.m. only 0.50 with other results proportional. It was evident that chlorine was rapidly lost either while dropping through the air or by action of the diluting water or by the glass. Results were not consistent among themselves.

An interesting series of experiments was next tried.

1. To 4.5 cc. of 22 p.p.m. chlorine solution, equivalent in color to 1 p.p.m. was added 1 cc. of orthotolidin. The color developed was the usual color (which we will call yellow for short, and read 1.2 p.p.m. on standards which we had modified somewhat from the original. Upon diluting the above with distilled water to the 100 cc. mark it read 0.8 p.p.m. Evidently diluting made a difference.

2. To 4.5 c.c. of 22 p.p.m. chlorine solution, equivalent as above to 1 p.p.m. chlorine, was added 0.1 cc. of orthotolidin. A deep red color developed. Diluted to 100 cc. and compared in small quantity it read 11 p.p.m. on the modified standards. On addition of 0.9 cc. of orthotolidin the color became yellow and read 1 p.p.m. Addition of 1 cc. of 1:1 hydrochloric acid produced no appreciable change.

The above was repeated, only adding the 0.9 cc. of orthotolidin before diluting. The red color turned yellow and read 1.1 p.p.m. Addition of 1:1 hydrochloric acid deepened the color slightly.

3. To 4.5 cc. of 22 p.p.m. chlorine solution, equivalent to 1 p.p.m. chlorine, was added 0.1 cc. of orthotolidin and 1 cc. of 1:1 hydrochloric acid. A deep red color developed immediately. Diluted to 100 cc. with distilled water and allowed to stand 12 minutes, the color then read 18 p.p.m. on the modified standards. Evidently the acid had deepened the red color by nearly 50 per cent in presence of the reduced amount of orthotolidin, while undiluted, which also remained after dilution.

4. To see if the problem was due to proportion of orthotolidin and chlorine chiefly, to 45 cc. of 22 p.p.m. solution, equivalent to 10 p.p.m. chlorine, was added 1 cc. of orthotolidin. A deep red color developed at once. After standing one hour it was diluted to 100 cc. and a small aliquot compared. It read approximately 240 p.p.m. chlorine.

Attempt was now again made to check the lower chlorine standards by measuring 0.1, 0.2, 0.3, 0.4, 0.5, and 1 cc. of the 22 p.p.m. chlorine solution into 1 cc. of orthotolidin in the Nessler tubes. After reacting for seven minutes they were diluted to 100 cc. with distilled water, thoroughly mixed and read. The values theoretically corresponded to 0.022, 0.044, 0.066, 0.088, 0.11, and 0.22 p.p.m. chlorine. The smaller values apparently had a constant minus error of about 0.012 p.p.m.

The first two values, representing 0.022 and 0.044 p.p.m. chlorine were repeated using 0.1 cc. of orthotolidin and 0.2 cc. of 1:1 hydrochloric acid in place of the regular 1 cc. of orthotolidin. The acid was to keep the concentration of acid as usual with 1 cc. of orthotolidin and only vary the latter. The results matched the standards closer, but there was no red color produced, indicating again that the red color was a matter of definite relative proportions of orthotolidin and chlorine. It was thought that this red color development

might lead to a method ten times more delicate in determining free chlorine, but it proved impracticable to vary the amount of ortho-tolidin and produce a scale, and furthermore the amount of chlorine in a water to be tested is usually unknown. Further tests along this line will be mentioned later.

Another attempt to avoid rapid consumption of chlorine and to minimize errors of measurement was made as follows: 1.36 cc. of the 22 p.p.m. chlorine solution was measured into 3 cc. of orthoto-

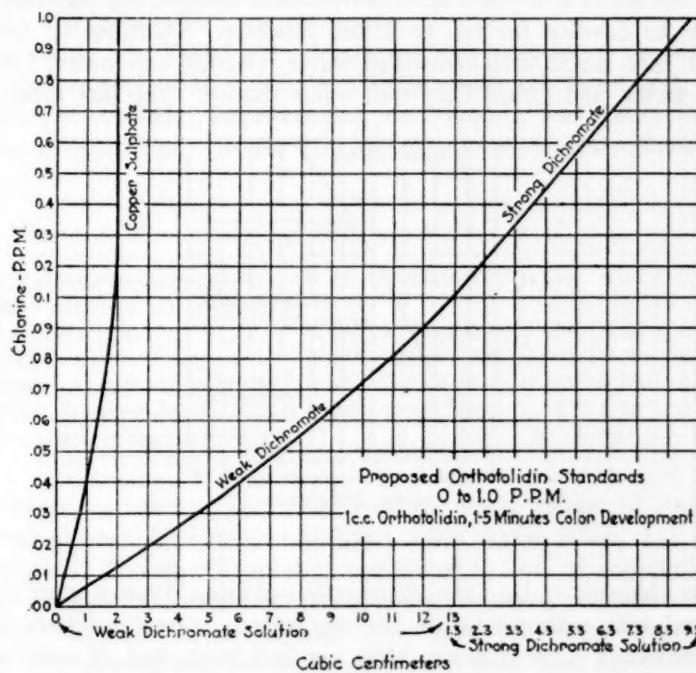


FIG. 3

lidin, the color developed and then dilution made with distilled water to 300 cc. volume. Varying quantities of this colored solution, 20, 40, 60, 80 and 100 cc., corresponding to 0.02, 0.04, 0.06, 0.08 and 0.10 p.p.m. chlorine, were then diluted to 100 cc. volume with distilled water containing 1 cc. of orthotolidin to every 100 cc. of water. The results again failed, all values reading about 50 percent of the expected values. It was thought that the distilled water might be largely responsible. Therefore 0.5 cc. of the 22 p.p.m.

chlorine solution was mixed with 1 cc. of orthotolidin, diluted to 100 cc. with the distilled water, mixed and read at once and then after ten minutes. The immediate reading was 0.11 p.p.m. chlorine and 0.055 after ten minutes. Thereafter redistilled water only was used and time was taken into account more seriously.

Several tests were now made on values corresponding to 0.022, 0.044, 0.066, 0.088, 0.11 and 0.22 p.p.m. chlorine by adding the required quantities of the 22 p.p.m. chlorine solution (0.1, 0.2, 0.3, 0.4, 0.5, and 1.0 cc.) to 1 cc. of orthotolidin solution and allowing the color to develop for ten to fifteen minutes. Dilutions to 100 cc. were then made with redistilled water, Catskill tap water, Croton tap water, and Grant City well water (hard). The last three had

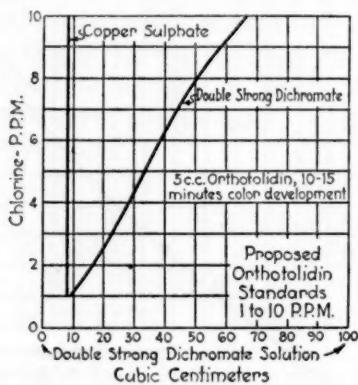


FIG. 4

been chlorinated by City chlorination plants. Blanks were determined with orthotolidin on the tap waters. Readings were made immediately after dilution, after one-half hour, and in some cases after one hour, with both modified standards and the original. Also higher values were halved and compared with lower. Also in one set the chlorine solution was added to the Nessler tube first and then the orthotolidin and in another set the reverse. Several facts were noted. Generally the modified standards were nearer the values expected. A constant minus error was again noticed. The halved solutions sometimes matched the lower values and sometimes not. The colors faded appreciably with time, with exception of those diluted with Catskill water which increased in the lower values. (This increase had been noted at the Catskill chlorination

plant previously.) Results were slightly higher using redistilled water when adding chlorine solution to orthotolidin than the reverse, indicating some effect either by the glass or loss of chlorine by diffusion into the air in the short interval before reaction with orthotolidin.

The values with redistilled water and the various City supplies corrected by the blanks were in good agreement on immediate readings. The idea in using the City supplies was to match conditions of use and to ascertain whether the salts present had any buffer effect. No buffer effect was noticeable.

The values which had been determined were compared on charts and the corresponding amounts of dichromate tabulated and the increments studied. Improvement was shown, but there were glaring irregularities. It was decided to make more determinations

TABLE 2
Average of early results

Value of chlorine solution, p.p.m.	0.022	0.044	0.066	0.088	0.11	0.22
Average readings on modified standards, p.p.m.	0.015	0.038	0.066	0.091	0.12	0.21
Differences, p.p.m.	-0.007	-0.006	0.000	+0.003	+0.01	-0.01
Minimum determinations, p.p.m.	0.005	0.025	0.05	0.075	0.095	0.18
Maximum determinations, p.p.m.	0.025	0.044	0.085	0.12	0.14	0.22
Number of determinations.	7	7	12	9	8	7

and obtain an average, particularly on the lower values, of several determinations. The range was 0.022, 0.044, 0.066, 0.088, 0.11 and 0.22 p.p.m. The chlorine solution was added to 1 cc. of orthotolidin in the Nessler tube, color developed fifteen minutes, diluted, mixed and read at once, after one-half hour, after one hour. Distilled water and various well waters, four sources, were used for dilution. The blanks determined were zero. Again colors faded with time, usually to about 50 per cent in an hour. Variations above and below the values expected occurred. The chief indication was that the standards in the neighborhood of 0.10 were low and this was corroborated also by reading one-half the upper determinations.

Table 2 contains a summary of results obtained up to this time which should have been trustworthy.

Chart studies were again made of these values and the averages appeared fairly good.

However, in order to approach nearer to the actual method of determination of chlorine in a water in which the orthotolidin is added to the chlorinated water and hence acts in dilute solution, another set of experiments was made comparing the method previously used which we will call "A" and a new method which we will call "B."

In "A" the chlorine solution was added to 1 cc. of orthotolidin, color developed five minutes, diluted with redistilled water, thoroughly mixed by pouring from tube to tube, and read at once.

TABLE 3
Comparison of methods "A" and "B"

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE (100 CC. VOLUME)	READINGS IN FIVE MINUTES	
		"A"	"B"
cc.	p.p.m.	p.p.m.	p.p.m.
0.1	0.02	0.02+	0.032
0.2	0.04	0.04-	0.04-
0.3	0.06	0.065	0.085
0.4	0.08	0.073	0.11
0.5	0.10	0.12	0.13
0.6	0.12	0.14	0.15
0.7	0.14	0.15	0.17
0.75	0.15		0.17
0.8	0.16	0.18	0.19
0.9	0.18	0.20+	0.22
1.0	0.20	0.20	0.24
1.5	0.30		0.31
2.0	0.40		0.38
2.5	0.50		0.52
3.0	0.60		0.62
3.5	0.70		0.82
4.0	0.80		0.85
4.5	0.90		1.12
5.0	1.00		1.2

In "B," 1 cc. of orthotolidin was added to redistilled water in the tube, making allowance for volume of chlorine solution to be added, and thoroughly mixed. The chlorine solution was then added, mixed as above, color developed five minutes and read.

Readings in "A" and "B" in several instances were also made after one-half hour, but the decrease in color was less than previously. The strong chlorine solution was made exactly 20 p.p.m.

and the entire scale was tested from 0.00 to 1 p.p.m. Practically all values by the "B" method were higher than by the "A" method. The results are shown in table 3 (modified standards).

The standards appeared low at several points by the "B" method. As it is believed that the "B" method approaches nearer to actual use and that the method giving the higher results is nearer correct owing to the tendency to quick loss of small amounts of chlorine, further experiments were started to modify the standards again to accord

TABLE 4
Determination of semi-final standards

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	READINGS						AVERAGES		DICHRO- MATE EQUIVA- LENTS
		Immediate			Five minutes			Imme- di- tate	Five min- utes*	
		cc.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	
0.05	0.01	0.015	0.016	0.017	0.010	0.016	0.015	0.016	0.014	1.9
0.1	0.02	0.027	0.025	0.028	0.020	0.021	0.026	0.027	0.022	3.2
0.2	0.04	0.055	0.055	0.058	0.050	0.050	0.053	0.056	0.048	6.2
0.3	0.06	0.082	0.086	0.088	0.065	0.084	0.085	0.085	0.080	8.8
0.4	0.08	0.12	0.12	0.12	0.095	0.12	0.12	0.12	0.11	11.8
0.5	0.10	0.13	0.13	0.13	0.12	0.12	0.13	0.13	0.125	12.7
0.75	0.15	0.17	0.18		0.17	0.17		0.17	0.17	1.6†
1.0	0.20	0.22	0.23		0.22	0.22		0.23	0.22	2.2
1.5	0.30	0.32	0.31		0.31	0.31		0.32	0.31	2.9
2.0	0.40	0.41	0.41		0.41	0.41		0.41	0.40	3.7
2.5	0.50	0.52	0.52		0.52	0.52		0.52	0.52	4.5
3.0	0.60	0.63	0.64		0.63	0.64		0.64	0.63	5.3
3.5	0.70	0.76	0.75		0.76	0.75		0.76	0.78	6.1
4.0	0.80	0.85	0.84		0.84	0.86		0.85	0.85	6.7
4.5	0.90	0.90+	0.90		1.04	1.02		0.9	1.06	7.8
5.0	1.00	1.2	1.2		1.2	1.24		1.2	1.21	8.5

* Includes "B" results of previous table

Includes B test
+ Strong solution.

with the "B" method results. Attention is also called to the necessity of repeating in succession several tests of the same value in the same Nessler tubes in dealing with small quantities of chlorine before minute losses of the chlorine are eliminated and the results become consistent.

In the next series of experiments results were obtained in duplicate for the entire range and triplicate for the lower range from 0.01 to 1 p.p.m. Readings were made immediately upon mixing and

also at the end of five minutes. Table 4 shows the results including averages and dichromate equivalents read from the charted standards. In the five minute averages were included the "B" results of the previous table. The dichromate values correspond to the higher averages, which occurred in the immediate readings except for the last two. (These two being above the standards were doubled from readings of one-half volume). All readings likewise were made in the same Nessler tube to eliminate the differences due to color of the glass.

A new set of standards was again made using the dichromate values of the last table, range 0.01 to 1.0 p.p.m. and another test with chlorine run off. The results were generally satisfactory with the exception of the higher range of the scale where the values still seemed somewhat low, although the colors did not exactly match in this portion of the scale. There is a conflict between the yellow color and the green, the former fading faster than the latter with time. There is a tendency for the green to predominate as time elapses. Somewhat higher standards were then tested for the following values:

CHLORINE VALUE p.p.m.	DICHROMATE SOLUTION	
		cc.
0.50		4.7
0.60		5.5
0.70		6.4
0.80		7.2
0.90		8.1
1.00		9.0

The results were sufficiently good and the colors lasted for one-half hour.

The amounts of copper sulphate as given in Standard Methods for the corresponding dichromate values had hitherto been used. No attempt was made to vary them in the range 0.10 to 1 p.p.m. (except slightly), since straight line values of dichromate appeared to give satisfactory standards and colors, with the possible exception of the extreme upper end. However there appeared to be no reason why the copper sulphate curve should not go to zero, consequently small amounts were chosen from an empirical curve and tried out and appeared to improve the colors without damaging the values. The above experiments were begun in January, 1923, and were

finished in May, 1923. In July the finally chosen standards were again tested with chlorine solutions under the adopted "B" method throughout the range 0.10 to 1 p.p.m. and the readings and colors were practically those desired except the slight off color of 0.9 and 1 p.p.m. just mentioned. No attempt was made to correct this as the values are rarely used and the colors will probably vary somewhat with different natural waters.

TABLE 5

Values of new standards finally chosen in range 0.01 to 1 p.p.m. (1 cc. orthotolidin)

CHLORINE p.p.m.	DICHRONATE cc.	COPPER SULPHATE cc.
0.01	1.8	0.3
0.02	3.2	0.5
0.04	6.1	1.0
0.06	8.7	1.4
0.08	11.0	1.7
0.10	1.3*	1.9
0.15	1.7	1.9
0.20	2.1	2.0
0.25	2.6	2.0
0.30	3.0	2.0
0.35	3.4	2.0
0.40	3.8	2.0
0.50	4.7	2.0
0.60	5.5	2.0
0.70	6.4	2.0
0.80	7.2	2.0
0.90	8.1	2.0
1.00	9.0	2.0

* Strong solution from 0.10 to 1.00.

The accompanying chart shows the smoothness of the values adopted and table 5 gives the values as they have been smoothed off. It may be mentioned that the higher values in the neighborhood of 0.10 p.p.m. were tested out at the well station where trouble had been experienced and the amount of residual chlorine was no longer higher than, but practically equal to, the dosage theoretically applied.

Mention has been made of varying colors produced under varying conditions, yellow, green and red. These are probably the products

mentioned in the literature.³ It was thought that possibly the very deep reds might develop a series ten times more delicate than the present standards. Hence varying experiments were conducted in

TABLE 6
Experiments with varying orthotolidin and 0.10 p.p.m. chlorine

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	ORTHOTOLIDIN	READINGS		COLOR
			Immediate	Five minutes	
cc.	p.p.m.	cc.	p.p.m.	p.p.m.	
0.5	0.10	0.05	0.08	0.12—	Yellow
0.5	0.10	0.10	0.12	0.12	Yellow
0.5	0.10	0.20	0.12	0.13	Yellow
0.5	0.10	0.50	0.13	0.12	Yellow
0.5	0.10	0.80	0.13+	0.13	Yellow
0.5	0.10	1.0	0.13+	0.13	Yellow
0.5	0.10	2.0	0.13+	0.13	Yellow
0.5	0.10	5.0	0.14	0.14	Yellow

TABLE 7
Experiments with varying orthotolidin and 1 p.p.m. chlorine

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	REACTION METHOD	DILUTING WATER	ORTHO-TOLIDIN	READINGS		COLOR
					Immediate	Five minutes	
cc.	p.p.m.			cc.			
5	1	"B"	Redistilled	0.05	90%	90%	Red
5	1	"B"	Redistilled	0.10	95%	133%	Red
5	1	"A"	Redistilled	0.10	10+p.p.m.		Red
5	1	"B"	Catskill	0.10	98%	100%	Red
5	1	"B"	Redistilled	0.20	80%	80%	Red
5	1	"B"	Redistilled	0.30	1.2 p.p.m.	1.2 p.p.m.	Yellow

Note: The percentage red color readings refer to the "A" experiment color as a comparison standard and were matched in a graduated tube.

order to find correct conditions. The readings are in terms of one of the intermediate experimental sets of standards and hence have only relative value. In the first series, varying amounts of orthotolidin were used with 0.1 p.p.m. chlorine, diluting with redistilled

³ Note on orthotolidin test for free chlorine, by W. F. Monfort, *Jour. Amer. Water Works Assoc.*, 1, 735, December, 1914; also paper by Ellms and Hauser mentioned above.

water and mixing the orthotolidin before adding the chlorine solution (method "B"). The results are shown in table 6.

No red colors were produced and values increased only slightly with increase in orthotolidin.

Another test was then made on the value 0.10 p.p.m. chlorine only adding the chlorine solution (0.5 cc. of 20 p.p.m. strength) to the 0.1 cc. of orthotolidin before diluting. The color was yellow both before and after diluting and read 0.12 p.p.m. both immediately and after five minutes.

Another series was carried out on the value 1 p.p.m. chlorine as indicated in table 7.

It is evident that the red color is produced whether the chlorine is added to the orthotolidin straight or diluted and that for 1 p.p.m.

TABLE 8
Experiments with varying parts per million chlorine and 0.10 cc. orthotolidin

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	ORTHO- TOLIDIN	READINGS		COLOR
			Immediate	Five minutes	
cc.	p.p.m.	cc.			
1.0	0.2	0.1	0.20 p.p.m.	0.21 p.p.m.	Yellow
2.0	0.4	0.1	0.40 p.p.m.	0.40 p.p.m.	Yellow
2.5	0.5	0.1	-5.0 p.p.m.	+5.0 p.p.m.	Orange
3.0	0.6	0.1	90%	95%	Red
3.5	0.7	0.1	85%	90%	Red
4.0	0.8	0.1	95%	133%	Red

Note: Percentage color readings refer to same standard as in preceding table.

chlorine the color change from yellow to red occurs between 0.3 cc. and 0.2 cc. of orthotolidin.

Another series was run off to determine at what strength of chlorine solution the red color was produced by 0.1 cc. of orthotolidin in 100 cc. volume, reaction "B," redistilled water, table 8.

It is evident that the color change from yellow to red with 0.1 cc. orthotolidin occurs at 0.5 to 0.6 p.p.m. chlorine which corresponds well with the results of table 7, 0.2 cc. orthotolidin for 1 p.p.m. chlorine.

The change of color seems too sudden and sharp, however, to be of use in a set of standards. It might serve as an extremely delicate test for certain values of chlorine, if made under precise conditions. In order to ascertain whether such an extremely delicate qualita-

tive test for minute amounts of chlorine could be developed from the red color reaction, the experiments in table 9 were carried out in April, 1924.

These experiments indicate no advantage nor greater delicacy in the red reaction in the low values.

It is interesting to note that a 0.10 p.p.m. aliquot of the original 20 p.p.m. chlorine solution which was about nine months old, read 0.11 p.p.m. on the proposed standards also about nine months old. This would indicate that the strong chlorine solution prepared in the manner described in this paper and stored in an amber colored glass bottle (glass stoppered) keeps well, and vice versa that the standards had faded only slightly. This fact may also prove of interest to those who determine the absorptive power of waters for chlorine by laboratory control in order to determine proper dosage.

TABLE 9
Additional red color experiments

CHLORINE VALUE p.p.m.	REACTION METHOD	ORTHO- TOLIDIN cc.	TIME minutes	ADDITIONAL HCl 1:1 cc.	READING* p.p.m.	COLOR
0.10	"B"	0.02	1		0.07	Yellow
0.10	"B"	0.02	1		0.07	Yellow
0.10	"B"	0.02	1	0.05	0.08+	Yellow
0.10	"A"	0.02	{ 1 10		0.12 0.18	Reddish Reddish
0.10	"B"	0.01	10		0.08	Red
0.15	"A"	0.02	1		0.25	Reddish
0.20	"A"	0.02	1		0.20	Reddish

* Read on proposed standards. Reddish colors estimated for depth of color since they did not naturally match in tint.

Our attention was next turned to the standards from 1 to 10 p.p.m. While not of general use in water work they may prove useful in connection with chlorination of oysters which has come into practice. Ellms and Hauser prescribed the addition of sufficient orthotolidin to produce the color without specifying a definite amount. In view of the experiments here described such a procedure seems hardly satisfactory, since the color varies in depth with amount of orthotolidin. Uncertain red colors might be produced also since 1 cc. of orthotolidin is only sufficient to produce yellow up to about 4 to 5 p.p.m. chlorine. It seems preferable to establish standards for a definite quantity of orthotolidin for the range.

The comparative effect of adding 3 and 1 cc. of orthotolidin to 1 p.p.m. chlorine was first ascertained on the finally chosen standard previously described. Duplicate tests were alike and 1 cc. orthotolidin read 1 p.p.m. chlorine equivalent to 9 cc. dichromate whereas 3 cc. orthotolidin read 1.2 p.p.m. equivalent to 10.7 cc. dichromate.

As a first try-out a set of ten standards was made up, containing from 10 to 100 cc. of the strong dichromate solution and with 10 cc. increments. The 2 cc. copper sulphate solution, as in Ellms and Hauser's standards, was added to each. The standards were arranged on a straight line, since that had been found satisfactory in the range 0.1 to 1 p.p.m.

TABLE 10
Tests with tentative standards, 1 to 10 p.p.m. chlorine, 3 cc. orthotolidin

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	STRONG DICHRO- MATE SOLUTION	COPPER SULPHATE SOLUTION	READINGS				
				Imme- di ate	Five min- utes	Ten min- utes	Fifteen min- utes	Thirty min- utes
cc.	p.p.m.	cc.	cc.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
5	1	10	2	0.9*	0.9*	0.95*		0.8-*
10	2	20	2	1.8	1.8+	1.8+	1.8+	1.8-
15	3	30	2	2.6	2.8	2.9	2.9	2.6
20	4	40	2	3.7	3.9	3.9	3.9	3.9
25	5	50	2		4.9	4.9	5.0	5.0
30	6	60	2		5.8	6.0	6.0+	6.0
35	7	70	2		7.0	7.0	7.0	7.0
40	8	80	2		7.9	8.0	8.0	N.G.
45	9	90	2		8.9	9.0+	9.0+	N.G.
50	10	100	2		9.9	10.0	10.0	N.G.

* The 1 p.p.m. readings were made on the lower standards. (In one and one-half hour this color had dropped to 0.5 p.p.m.)

Table 10 shows the results of tests compared with the above standards and read at time intervals up to thirty minutes. The orthotolidin, 3 cc., was diluted with redistilled water and well mixed making allowance for the volume of chlorine solution to be added, the latter added and well mixed. Mixing was accomplished as in the previous work by pouring from tube to tube several times.

The standards in the lower range were slightly high. From 6 to 10 p.p.m. the color matched poorly since the chlorine solutions showed more green content and this increased with time. It was decided that colors developed in ten to fifteen minutes were maximum.

Attempt was next made to match the colors by adding more copper sulphate and correspondingly increasing the dichromate, allowing ten to fifteen minutes for color development. After preliminary experiments a dichromate solution double the strength of the strong solution was made. A trial series was run using 3 cc. orthotolidin as shown in table 11.

TABLE 11
Tests with 10 cc. copper sulphate

CHLORINE VALUE <i>p.p.m.</i>	DOUBLE STRONG DICHROMATE <i>cc.</i>	COPPER SULPHATE SOLUTION <i>cc.</i>	READING (TEN MINUTES) <i>p.p.m.</i>	DICHROMATE EQUIVALENT <i>cc.</i>
1	13	10	1.0+*	10
2	18	10	1.9	17
3	23	10	3.2	24
4	28	10	4.8	31
5	33	10	6.0	38

* One part per million read on lower standards.

TABLE 12
Test of experimental standards with 10 cc. copper sulphate and using 3 and 5 cc. orthotolidin

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	DOUBLE STRONG DICHROMATE	COPPER SULPHATE SOLUTION	READINGS TEN TO FIFTEEN MINUTES (ORTHOTOLIDIN)		
				3 cc., first set	3 cc., second set	5 cc., third set
cc.	p.p.m.	cc.	cc.	p.p.m.	p.p.m.	p.p.m.
5	1	10	10	1.0+	1.2	1.0
10	2	17	10	2.0-	2.0	2.0+
15	3	24	10	2.9-	3.0	3.0+
20	4	31	10	4.0+	4.0	4.1+
25	5	38	10	5.0+	5.0	5.0+
30	6	45	10	5.8	5.8	6.0
35	7	52	10	6.4	6.2	6.8
40	8	59	10	7.2	7.0	7.4
45	9	66	10	7.8	9.2	8.5
50	10	73	10	9.0	9.5	9.5

A new set of standards was now made based on the dichromate equivalents and straight line increments, and three tests of the entire range made, using 3 cc. orthotolidin in the first two and 5 cc. orthotolidin in the third and the "B" method. Table 12 shows the results.

The higher half of the scale showed irregularities and colors did not match as they should, the green predominating too much. The larger amount of orthotolidin helped some and was adopted after further trials.

TABLE 13
Final tests using 8 cc. copper sulphate
Five cubic centimeters orthotolidin, ten to fifteen minutes

CHLORINE SOLUTION (20 P.P.M.)	CHLORINE VALUE	COPPER SULPHATE SOLUTION	DOUBLE STRONG DICHRO- MATE	READINGS		DICHROMATE	
				Trial set	Test set	Adopted	Increments
cc.	p.p.m.	cc.	cc.	p.p.m.	p.p.m.	cc.	
5	1	8	9	1.0-	1.0	9	9
10	2	8	16	2.0	2.0+	16	7
15	3	8	22	3.0	3.0	22	6
20	4	8	28	4.0-	4.0-	28	6
25	5	8	33	5.0+	5.0+	33	5
30	6	8	40	5.9	6.2	38	5
35	7	8	44	6.9	7.0+	44	6
40	8	8	49	7.8	8.0	50	6
45	9	8	58	9.2	9.0	57	7
50	10	8	67	10.0	10.0+	66	9

TABLE 14
Value of new standards finally chosen in range 1 to 10 p.p.m.
Five cubic centimeters orthotolidin and ten to fifteen minutes color reaction

CHLORINE	DICHROMATE (DOUBLE STRENGTH)*	COPPER SULPHATE
p.p.m.	cc.	cc.
1	9	8
2	16	8
3	22	8
4	28	8
5	33	8
6	38	8
7	44	8
8	50	8
9	57	8
10	66	8

* Twenty times the strength of the present standard dilute solution.

Reducing the copper sulphate somewhat was next tried and, without giving the intermediate tests, it was decided that 8 cc. best

matched the colors, particularly in the lower part of the scale. In order to keep the amount of copper sulphate constant at 8 cc. for each standard it was decided that a constant increment of dichromate would have to be abandoned in this range. In order to control the time element, since the proportion of green and yellow changes with time, another set of experiments was carried out in which an amount of dichromate slightly below the color desired was added to make the standards and additional dichromate, 1 cc. at a time, added to match the chlorine test color at ten to fifteen minutes. Additional standards were then made up with the indicated amounts of dichromate and tested with chlorine solution again. The results were then charted and slight modification made in a few to render the increments of dichromate consistent. Table 13 shows these results in two sets of tests with the values chosen, using "B" method and 5 cc. orthotolidin.

Check titration of the chlorine solution at the finish showed it to be exact. It will be noted that in a general way the ratio of amounts of copper sulphate in the proposed and present standards is 4:1 and the average amounts of dichromate 2:1.

The final chosen standards for range 1 to 10 p.p.m. chlorine, using 5 cc. orthotolidin are given in table 14.

The accompanying chart shows the smoothness of the double curve of dichromate.

It is emphasized that throughout this work great care has been exercised in frequent cleaning of glassware with cleaning mixture and in preparation of redistilled water.

Note: For completeness and for the advantage of any who possibly may not possess Standard Methods, or Ellms and Hauser's original paper, the following is the method of preparation of the reagents used in making the colorimetric standards and the orthotolidin:

Orthotolidin reagent

Dissolve 1 gram of orthotolidin, m.p. 129°C. in 1 liter of dilute hydrochloric acid (100 cc. concentrated acid diluted to 1 liter).

Copper Sulphate solution

Dissolve 1.5 grams of copper sulphate in distilled water containing 1 cc. of concentrated sulphuric acid and make up to 100 cc.

Dichromate solution weak

Dissolve 0.025 gram of potassium dichromate in distilled water containing 0.1 cc. of concentrated sulphuric acid and make up to 100 cc.

Dichromate solution strong

Dissolve 0.25 gram of potassium dichromate in distilled water containing 1 cc. of concentrated sulphuric acid and make up to 100 cc.

Dichromate solution double strength

Dissolve 0.5 gram of potassium dichromate in distilled water containing 2 cc. of concentrated sulphuric acid and make up to 100 cc.

Make the standards and determinations in 100 cc. Nessler jars having the 100 cc. mark at 24 cm. height.

SHALLOW WELLS OF IOWA¹

BY H. V. PEDERSEN²

A well is considered shallow in Iowa when it ranges from 1 to 100 feet in depth. If you were to fall headlong into a dug well 100 feet deep, with only a few feet of water in it, you would no doubt have some difficulty in understanding why the State Board of Health has arbitrarily set the limits of a shallow well at 100 feet. There is no particular reason for calling a well 100 feet deep shallow except when it is compared with some of the deeper wells in Iowa. Those cities and towns of the state that have drilled down into the earth's crust to secure the water flowing through the St. Peter and Jordan sand stones have wells ranging all the way from 100 to 2300 feet in depth. Comparing a well 100 feet deep with one 2300 feet deep gives ample justification for calling the former shallow.

Taking the state as a whole, there are many more shallow wells than there are deep wells, but, if we deal with municipal water supplies only, the shallow wells are slightly in the minority at the present time. Most of the municipal wells in the northern part of the State are deep, while a number of the towns in the southern part have given up their shallow supplies for the deeper wells or surface supplies.

Practically every type of shallow well is found in Iowa. There are the dug, bored, and drilled wells, besides the sand points. The dug well is rarely deeper than 50 feet, and is usually no less than 10 feet in diameter for public wells and 4 feet for private and is usually cased with brick, sometimes with concrete, and occasionally with cement blocks. Bored wells range all the way from 15 to 80 feet in depth and are usually cased up with clay or concrete tile. The drilled shallow well is constructed similar to the deep drilled well, is usually cased with regular wrought iron or steel casing and pumped by a deep well pump outfit. Sand points are common in localities where a shallow water bearing gravel underlies a town and is constructed usually by driving a sand point connected to a pipe directly down into the gravel.

¹Presented before the Iowa Section meeting, October 25, 1923.

²State Sanitary Engineer, State Board of Health, Des Moines, Iowa.

The type of shallow well that is commonly installed in a community depends upon the underground strata and upon custom. The writer believes that the reason the majority of the wells in some communities are dug, while the majority of wells in another are of the bored type, is due to custom more than anything else. Possibly some old settler when first locating in a certain place chose to install a well of a bored type. Neighbors coming in, seeing the bored well, also chose to have one. When the community sprang up every one had seen so many bored wells that they just took for granted that that was the only type of well for their community.

There is no particular type of well that may be given preference to the exclusion of all others, as far as sanitation is concerned. If one community prefers a series of bored wells to one large dug well there is no particular reason why they should not have their way, as long as due precaution is taken to prevent surface waters from entering the wells. Certain conditions, however, do govern the type of shallow well that is constructed in various communities. It would certainly not be economical to dig a well down into a rock formation where a drilled well would furnish the required amount of water. In sandy places it would not be practical to attempt to bore a well when the sinking of a large brick or concrete constructed casing would be much more simple. Certain types of wells have an economical advantage over others when located in certain earth formations, but there is really little reason for choosing any particular type of well because of sanitary aspects.

All types of shallow wells should be protected from surface waters. The kind of a well to install is not nearly as important as the location of the well. Improper location is the root of all evil. Time and time again we have been forced to blame the unsafe quality of the water supply upon the improper location of the well. Sometimes faulty construction is directly to blame, but our opinion is that, if the well had been located properly, the faulty construction would not have been considered serious.

Public shallow wells are generally located in the low lands or valley of some small creek or river. Wherever it is practicable, the well should be located above the town rather than below it. No shallow public well should be located inside the city or town limits unless it is the only possible location. The further upstream a shallow well is located from a community, the better the location is considered.

Next in importance to the location of the well is its construction. Every type of well, wherever located, should have a water-tight cover, and the casing should be constructed water-tight down to at least 12 feet below the surface of the earth. Bored wells seldom have tight joints due to the use of tile as a casing. A joint of a common tile casing is not easy to cement, so all well drillers should be required to use a few bell and spigot pipes near the surface in order that a good cement joint may be made.

Pump pits should be dispensed with entirely in all new construction, where the pump is above the surface of the ground. Where pumps are placed in a pit below the surface of the ground, in order to keep within the suction limit of the pump, a good sump hole should be provided for collecting all spilled water. Such a sump hole should never be connected directly to a sewer for drainage, but should preferably be emptied by either a hand pump or a small power pump.

The practice of setting the pumps on a platform down in the well should be discontinued. A well makes a very poor pump pit and represents the poorest type of water works construction. The pump pit should be located at a reasonable distance to one side of the well and should not be connected to the well by any other way than the suction pipe of the pump.

Many of the water bearing sands of the state, where shallow wells are located, contain a great amount of iron and other impurities. For this reason, much of the water from shallow wells is not palatable or satisfactory for domestic use. Many of these shallow well supplies are maintained, however, because of the great quantity of water available at low pumping costs. If the various communities of Iowa were to locate shallow wells properly and construct them so as to exclude all possible surface contamination and then provide aeration to remove the iron, there is no reason why the shallow wells of Iowa should not be a satisfactory source of public water supply for many years. It has only been a direct violation of a few general sanitary laws that has caused the shallow well in Iowa to lose its good standing and to be considered an unsafe source of water supply.

ORGANIZATION AND PROGRAM OF THE SEWAGE SUB-STATION AND SOME RESULTS OBTAINED¹

BY WILLEM RUDOLFS²

Assuming that most of the sewage disposal plants in the United States are based on biological purification it is surprising to note that comparatively little research has been carried on by biologists (bacteriologists, zoölogists and botanists) on the organisms involved. Studies to improve and devise methods of biological sewage purification have been made mainly by engineers and chemists.

Due to unexplainable troubles in operating sewage disposal plants the Engineering Division of the New Jersey State Department of Health made an effort some ten years ago to secure money for an investigation, but nothing was done. Following a series of complaints from the neighboring population of the joint sewage disposal plant of Plainfield, North Plainfield and Dunellen, N. J., with regard to numerous small flies (*Psychoda alternata* Say) the Entomologist of the New Jersey Agricultural Experiment Station was consulted on the possibility of eliminating this nuisance. As a result of a study, which successfully accomplished this object, some information was secured on the part biological life played in sewage purification. The Agricultural Experiment Station became interested in the utilization of fertilizers now mostly wasted and acting together with the New Jersey State Department of Health and with the coöperation of the New Jersey Sewage Works Association an appeal was made to the Legislature for funds to carry on fundamental research concerned with the underlying principles of biological sewage disposal. An act was passed in 1920 authorizing the Agriculture Experiment Station and the Department of Health to "conduct an investigation of

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² Chief, Sewage Investigations, New Jersey Agricultural Experiment Stations, New Brunswick, New Jersey.

the biology of sewage disposal, to the end that more effective methods of sewage purification may be discovered and applied to the purification of sewage."

The sewage substation was started July 1, 1921, with a sewage specialist and a chemist.

A controlling committee was appointed consisting of a representative of the Agriculture Experiment Station, a representative of the Department of Health and the Chief of the Sewage Substation. An advisory committee consisting (at present) of two sanitary engineers, a chemical engineer and a practical sewage operator was appointed by the New Jersey Sewage Works Association.

In October, 1922, the sewage substation was reorganized and a chief of sewage investigations, a bacteriologist, a protozoologist, a chemist, a botanist and a laboratory assistant appointed. This allowed us to attack the problem from different angles and carry a specific piece of research to a finish.

For an initial study the Plainfield sewage plant consisting of 6 Imhoff tanks, sprinkling filter beds and final settling tanks was chosen. This plant treats from 3 to 4 million gallons sewage per day and takes care of the sewage of 40,000 people. Of the 6 tanks at this plant, 3 operate while 3 are resting. The groups of tanks alternate in various combinations. This arrangement is an advantage to us because it gives something of the flexibility of an experimental unit without sacrificing the size and stability of practical tanks. The tanks can and are manipulated to suit the purpose of an experiment. Although at present engaged in the study of the biology of Imhoff tanks, which we hope will ultimately lead to an improvement of this special method of sewage disposal, we feel that the results secured from an intensive study of the underlying principles of the biological and biochemical changes of such a practical plant may possibly be applied to other methods of biological sewage disposal. We have found already in the study of this type certain analogies with the activated sludge and septic tank processes. However, when time is ripe we will endeavor to study more in detail and correlate other processes as well.

PLAN OF INVESTIGATION

A general outline shows the type of fundamental work in progress and planned on sludge digestion and sewage purification.

1. Chemical studies of relative and definite amounts of the intermediate and end products of biological activity, i.e., organic acids,

NH_3 , N_2 , CO_2 , CH_4 , H_2 and the resultant compounds (carbonates, sulfates, H_2S , etc.) in all parts of the Imhoff tanks and filter beds, and their variation under different conditions. Bacteriological work in this connection includes studies on proteolysis and metabolic products of proteolysis; effect of H-ion concentration on the digestion of complex proteins, etc. Protozoölogical work includes food intake and excretion products.

2. Digestion changes in fresh solids, scum and sludge. This includes studies on chemical products formed; microörganisms concerned with formation of indol, skatol, production and use of organic acids, organisms able to attack fats; relation of melting point of fat and digestion; effect of soap on the rate of fat digestion, etc.

3. The fate of paper in sewage. Digestion of cellulose and other complex carbohydrates. Relation of protozoa and bacteria in this process; determination and measurement of gases produced.

4. Nitrogen transformation. (NO_3 , NO_2 , NH_3 cycles and the influence of temperature.) Interrelation of nitrification and denitrification. Effect of pH and oxygen tension on the course of nitrogen transformation.

5. Sulfur transformation.

6. Studies on the physiology of the dominant protozoa and their mechanical work. Similar studies on Nematodes and Annelid worms. Influence of seasonal changes on the occurrence of animal froms. Methods of increasing or decreasing specific groups of protozoa if necessary or desirable.

7. Classification of algae and fungi and a study of the physiological activities of the most prominent forms. Influence of seasonal changes. Nutrition studies.

8. Isolation and identification of important bacteria in sewage purification and relative importance of physiological activities. Anaerobic bacteria, their numerical relation to aerobes, etc.

We endeavor to publish our findings, which may be of interest to the investigators in this or allied fields and to the sanitary engineer or practical sewage plant operator as soon as suggestions can be made or conclusions reached. Up to date several papers and reports have been published on the progress of the work.

IMHOFF TANKS

Most of our studies during the last year have been concerned with digestion changes taking place in the tanks. Our effort has been to

correlate the occurrence and numbers of protozoa and occurrence and numbers of bacteria with the chemical changes taking place.

Botanical observations have brought out the fact that microscopic plant life is practically absent in the tanks. Sometimes filamentous bacteria occur in the scum, but these organisms do not occur in sufficient quantities and regularity to have any pronounced effect upon the course of digestion.

Studies on animal life in the tanks proved highly interesting. There are mainly two groups of microscopic animals in the tanks, namely, ciliates and flagellates; the flagellates are by far more abundant. The relation as a rule between these groups is 10 flagellates to one ciliate. In a normal tank we find per cubic inch the following numbers:

	FLAGELLATES	CILIATES
Scum.....	160,000	Few
Liquid.....	450,000	12,000
Sludge.....	240,000	140,000

When conditions are favorable for them they increase rapidly and might be of importance for the working of the tank. From our observations it seems that the increase is the result of changing conditions, brought about by bacterial action, rather than the cause. However, when their numbers become sufficiently large there may be a decided factor in changes produced.

Bacteriological work has also been concentrated on one of the Imhoff tanks. The samples examined were from the influent to the tank and from the effluent and from the scum, liquid and sludge of the digestion chamber of the tank chosen for observation. The activities chosen as criteria were the digestion of albumin, the formation of hydrogen sulfide from protein, the reduction of nitrate and nitrification changes. The bacteria in the scum far outnumbered the bacteria found in the rest of the digestion chamber. The bacteria in the liquid and sludge were more nearly comparable in numbers. There were marked fluctuations in numbers of organisms in the digestion chamber at the different times when the samples were taken. The samples from the influent and effluent, however, did not vary greatly in their bacterial content from week to week.

As an example to correlate chemical, bacteriological and zoological data the same results from an experiment made during this winter

are presented in table 1. These figures are from a tank which had been alternately operating and resting. If we consider the behavior of the tank, from these figures we see that fresh solids are coming in at such a rate that the bacteria are increasing rapidly to a high peak. Apparently these bacteria were mainly responsible for the rapid rise of CO_2 content in the gases produced. The production of high CO_2 is paralleled by an increase or dispersion of solids in the liquid. The dispersion of the solids seemed favorable to the animals and gave them a chance to multiply rapidly. Shortly before the dispersion of these solids (embedding bacteria) reached its peak the numbers of

TABLE 1
Changes occurring in an Imhoff tank alternately operating and resting

DATE	OPER- ATING OR RESTING	BAC- TERIA*	GAS (CO_2)	SOLIDS	ANIMALS†	NH_3	pH
		millions					
January 3.....	O	35.9	30.0	1.7	12.9		
January 5.....	O		30.6	2.7		400	7.0
January 7.....	O	222	31.5	3.15	12.9	450	7.1
January 10.....	O	303	33.1	5.85	11.9	475	7.1
January 14.....	R	92	29.4	3.4	66.8	475	6.9
January 16.....	R	174	29.8	2.9	118.2	475	7.2
January 19.....	R		28.0		155.5	550	7.3
January 21.....	R	72	27.8	1.79	48.4	750	7.3
January 24.....	O	82	26.5	1.27	24.3	460	7.5
January 26.....	O	119	27.8	1.90	41.2	400	7.7
January 28.....	O	51	28.0	0.53		450	7.3
January 31.....	O		30.6	1.20		425	7.2
February 2.....	O	53	31.7	0.73	40.9	425	7.3
February 4.....	O	105	31.6	2.28	69.5	425	7.0

* Millions bacteria per gram moist material.

† Thousands of animals per cubic centimeter.

bacteria began to decrease and continued to do so until the tank was put out of operation. While no fresh solids were coming in bacteria multiplied again. It is possible that another group of bacteria attacking partly decomposed material became more prominent. With the settling of the solids the medium became less favorable for the animals and they died off. The production of ammonia in the closed tank went on and the accumulation of NH_3 together with the dying microscopic animals accounts for the high peak of ammonia reached during the resting period. It is of interest to note the wave like increase and decrease of bacteria. We have some evidence to

believe that this is caused by the attack of materials in the tank by different groups of bacteria. Certain substances are produced by certain bacteria. The chemical products or resultant substances are in turn used by other groups of bacteria. At the same time it is possible that the production of certain substances make a more favorable medium for the latter organisms. These problems will be investigated as soon as possible.

As was pointed out before, a general survey of different groups of bacteria was made of the whole plant. After the data were accumulated, averages were made in order to obtain a picture of the bacterial flora. Seven groups of bacteria were found to be of sufficient numerical importance to allow of their consideration as organisms important in the purification of sewage. As judged by their physiological activity, they are bacteria which are engaged in proteolysis and the transformation of nitrogen and sulfur. They may be divided into two types: the bacteria producing reduction changes and the bacteria producing oxidizing changes. The seven specific groups of organisms studied were:

1. Organisms reducing nitrate to nitrogen gas.
2. Organisms splitting protein with the production of hydrogen sulfide.
3. Organisms liquefying coagulated egg albumin.
4. Organisms reducing inorganic sulfates to hydrogen sulfide.
5. Organisms oxidizing ammonium salts to nitrites.
6. Organisms oxidizing nitrites to nitrates.
7. Organisms oxidizing thiosulfite to sulfate.

The largest average number of bacteria per cubic centimeter occurred in the digestion chamber of the Imhoff tank, while the effluent from the sprinkling filter, contained the lowest average number of bacteria per cubic centimeter. The average in the final effluent, after the sewage had passed through the final settling tank, was higher than the average of the sprinkling filter effluent.

In the seven groups studied the bacteria which were most abundant throughout the plant were the nitrate reducers, those which produced hydrogen sulfide from protein, and the albumen digesters. Although the nitrifying and sulfur oxidizing bacteria were not nearly so numerous, they were found consistently throughout the plant and even occurred regularly in the digestion chamber of the Imhoff tank.

SPRINKLING FILTER

In an effort to learn more about the growth around the stones at different levels of the filter beds ordinary bricks were placed in sampling holes and scraped free from material at regular intervals. The amounts of wet film were weighed separately and the material used for identification in the botanical, protozoölogical and bacteriological studies. The method used is without doubt faulty and we have just completed a method of sampling which will allow us to leave tiles to be used in place for at least one year. Nevertheless we have obtained with our old method some interesting information on the flora and fauna of the filter bed.

The seasonal distribution of fungi in the filter and a possible correlation between the fungi and biological activities is of interest. The most significant changes occurring are the periodic sloughings of the film and the subsequent clogging of the beds. The species of plants vary. They appear throughout the bed, but there is a tendency for the fungi to be more abundant towards the top of the bed, and decrease downward. *Beggiatoa*, which uses sulfur for energy, and filamentous bacteria seem to be more abundant at the lower depths.

Seasonal changes are quite marked. *Penicillium* disappears in the spring and comes back in the summer, increases steadily until the winter when it reached its maximum and decreases again until it disappears in the spring again. *Dictyuchus*, another fungus, appears in largest amounts in the early spring, disappears almost entirely during summer and fall, reappears in midwinter to reach its maximum again in the early spring. One other significant point is that the microscopic plants are very scarce during the summer months. During this time however, *Beggiatoa alba* and filamentous bacteria are at their maximum.

On analyzing and averaging the bacteriological data secured in an examination of the film which surrounds the stones of the sprinkling filter, a picture of bacteriological conditions in the sprinkling filter bed was obtained. The reducing bacteria as a whole outnumbered the oxidizing bacteria but there was a tendency for the reducing bacteria to decrease in the lower levels of the bed while the oxidizing bacteria increased, until, in the 5-foot level of the bed there was no longer a marked predominance of reducing organisms. When the denitrifying bacteria (those producing nitrogen gas from nitrate) were considered, it was observed that 34 per cent of those found occurred in the surface film and 55 per cent in the 5-foot level. In the film also, the

hydrogen sulfide producers decreased as the depth at which the samples were taken increased. The albumen digesters, which may be considered as a type of the proteolytic organisms, maintained a fairly constant abundance throughout the filter bed.

It has been said that the oxidizing organisms tended to increase with the depth of the filter bed. The sulfur oxidizing bacteria and the nitrite producing bacteria showed the highest rate of increase between the surface and the 3-foot depth. The nitrate producing bacteria are dependent upon the nitrite producing forms. These organisms increased slowly from the surface and the 3-foot depth, but, in the average of the samples taken from the 6-foot depth, they showed an enormous increase. For example, only 3 per cent of the nitrate producers were found in the samples from the 3-foot level and 92 per cent were found at the lowest level.

These results show conclusively the great importance of the film around the stones for the purification processes. Consequently the importance of finding out all phenomena connected with the building up and the removal of the film. When we know more about these phenomena the way is clear for studies to increase the efficiency of the filter beds.

FRESNO CITY WATER CORPORATION¹

BY E. K. BARNUM²

HISTORICAL DESCRIPTION

Quoting from a report made by the J. G. White Company in 1911 it is said,

That the early history of the Fresno City Water Corporation's property is somewhat vague, due to various changes in financial vicissitudes and no positive information in regards to its corporate or operating history is available prior to 1902 when the property passed through a receivership and was later purchased by the present owners. The property is the result of a process of development following to a considerable extent the growth of the City of Fresno. The physical plant of today (1911) adequately serves the community and, by the rather unique arrangement of pumping plants, pressures are well equalized. The quality of water has been passed upon by competent authorities and is said to be excellent. Briefly the system consists of an electrical substation, now under construction, from which the power purchased from the San Joaquin Light and Power Corporation will be distributed to 9 motor driven pumping plants having a combined capacity of 595 H.P. and located with due regard to the requirements of the community. The distribution system includes 68.02 miles of pipe, 3 to 12 inches in size, supplying approximately 4500 services.

From available records it is conservatively estimated that the population in Fresno, in the year 1911, when the above was compiled, was about 30,000 inhabitants. On this basis there was then 6.67 people per service, and about 66.2 services per mile of main installed.

FRESNO OF TODAY

The population of Fresno today is estimated to be 69,000. This figure is based on the entire area served by the water company or approximately 6 square miles. The rapid growth of the city, it might be said, is due to the general prosperity enjoyed throughout the San Joaquin Valley. There are now 182½ miles of dedicated streets in Fresno, of which 46 miles or 25.2 per cent are paved with

¹ Presented before the California Section meeting, October 26, 1923.

² Engineer, Water Corporation, Fresno City, California.

asphalt and concrete. The entire water supply is furnished by means of pumping from the underground waters. Within this area of 6 square miles there has been constructed 27 pumping plants, having a total capacity of 33,440 gallons per minute against the total head of 140 feet or 48.15 million gallons per day. Perhaps it would be interesting at this time to say a few words regarding the water table from which we are drawing this supply. The general slope of the percolating water is in a southwesterly direction and represents the normal course of movement of the underground waters towards the floor of the Valley. In "Water Supply" paper No. 398 of the U. S. G. S. by Mendenhall, Dole and Stabler, it is said that

The area of the valley is 11,500 square miles. The depth of the sands and gravels, which are saturated with the ground water, is probably not less than a mile at a maximum and maybe much more. The average depth is equally unknown, but wells one thousand feet deep, or even more, are scat-

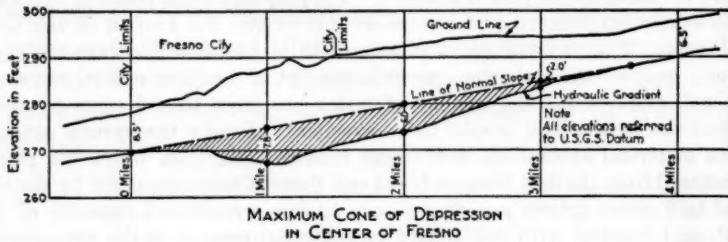


FIG. 1

tered throughout the Valley, and do not reach the bottom of the unconsolidated sands and gravels, so it may safely be assumed to be one quarter of a mile or more. At this depth nearly 3000 cubic miles of sands, gravels and clays are saturated with ground waters and, if the porosity is 20 per cent, the conclusion is reached that 600 cubic miles of water underlie the valley, certainly both a sufficiently conservative and startling estimate, but this includes water of all qualities, some not usable and some lying at great depths and not accessible.

Figure 1 is a transverse profile extending east and west throughout the center of Fresno and shows the hydraulic gradient of the major cone of depression due to a pumpage of about 25 m.g.d. The maximum length of the vertical axis of this cone or the difference in elevation between the average slope line of the normal water table and point of greatest depression is only 9 feet. This it is believed is a reflection of the tremendous quantity of water available. As the city grows and expansion takes place, which means additional pump-

ing plants, it is apparent that this major cone of depression will expand along its horizontal axis more rapidly than in a vertical direction, thus increasing the pumping lift but little compared to the expansion in width.

WELLS AND PUMPING PLANTS

The average capacity of all 27 stations is 1238 gallons per minute per station, total lift 140 feet. Stations 3 and 26 to 29 inclusive are deep well turbines, No. 6, 3 stage, Bryon-Jackson with a rated capacity of 1600 gallons per minute, 140 foot total lift, 1165 r.p.m. The balance of the plants are of the centrifugal type, double suction,

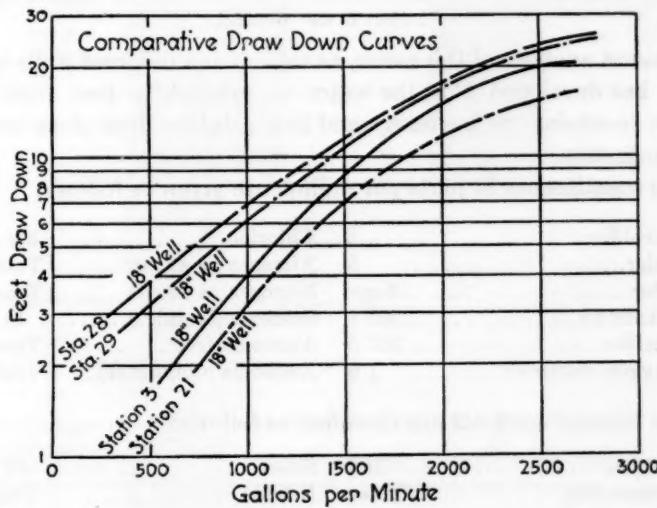


FIG. 2

direct connected, and pumping from 2 or more wells. Station 1, which is considered rather unique, is located at Fresno and O Street, just bordering on the principal mercantile district. This station is one of the early developments of the water company and has a rating of 1750 g.p.m., total head 124 feet, receiving its supply from 11 different wells, ranging in depth from 150 to 900 feet. The 18 inch wells recently put in operation under test have shown remarkably good characteristics. The well at Station 29 is approximately 130 feet deep and was sand pumped and developed up to approximately 300 gallons for a period of two weeks before connecting to the mains. During this test observations were made of the discharge by means of

a calibrated orifice and corresponding draw-down measurements observed. From these data performance of each well was obtained and plotted. These curves are shown on figure 2. It will be seen that for Station 29, when yielding 1600 gallons per minute, that the draw-down is but 12 feet, while for the same yield Station 27 shows but 8 feet draw-down. Figure 3 is typical of the Fresno Wells. The centrifugal, double suction, units are pumping from 12 inch open bottom wells. Where two or more wells are provided, the casting is landed so as to tap the upper water bearing sands which are found at an average depth of 25 feet, while the second landing taps the lower water bearing strata at an average depth of 225 feet.

PURITY OF WATER

A recent analysis of the water, as taken from different wells in the City, has developed that the water is practically free from turbidity, contains no bacteria, and is absolutely free from surface contamination.

The constituents in parts per million are given as follows:

Turbidity.....	5	Chlorine.....	324.5
Color.....	5	Nitrogen as nitrate.....	Trace
Odor.....	None	Nitrogen as nitrite.....	Trace
Alkalinity.....	162.4	Suspended solids.....	18
Residue.....	227.5	Ammonia free.....	Trace
Oxygen consumed.....	1.6	Ammonia albumenoid.....	Trace

The mineral contents are classified as follows:

Sodium.....	20.6	Silica.....	31.2
Ammonium.....	Trace	Nitrate.....	Trace
Magnesium.....	9.12	Sulphate.....	14.2
Calcium.....	39.74	Chlorine.....	24.5
Iron, per cent.....	2.6	Bicarbonate.....	178.5

Hypothetical combination:

Calcium bicarbonate.....	161.9
Magnesium bicarbonate.....	56.7
Sodium chloride.....	40.39
Sodium sulphide.....	18.9
Silica.....	31.2
Iron and alumina.....	2.6

In conclusion, chlorine as chlorides is generally considered one of the most constant and principal constituents of sewage. The test

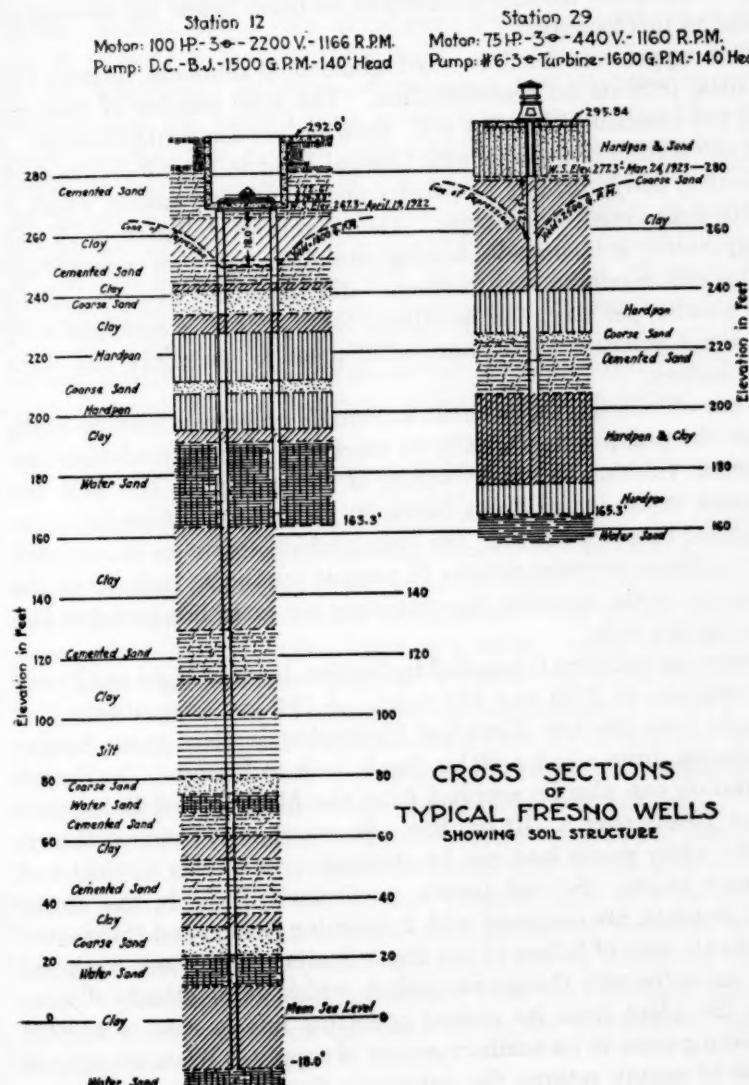


FIG. 3

above shows the chloride contents to be much below the average as found in this locality.

The oxygen consumed, free and albumenoid ammonia, nitrates and nitrites, indicate no contamination. The total number of bacteria and the absence of bacillus coli show no surface contamination.

Each station is provided with General Electric Type F-3 combined recording and indicating flow-meter and bronze flow nozzle, which is of the submerged orifice type. The records are collected daily and computation is then made showing total discharge from each station, hours run, maximum and minimum discharge, and average gallons per minute per day. In addition, each station is equipped with recording pressure gages, automatic pressure governors and watt hour meters.

Your attention is called to the automatic pressure governors which allow the pump automatically to start and stop at predetermined pressure values. In other words, if the pump is idle and the pressure in the mains drops below 30 pounds per square inch, the contactor operates starting the pump which continues to run until the maximum pressure obtains 50 pounds per square inch, when the contactor again operates, disconnecting the main line switches and stopping the unit.

Power for pumping is supplied by the San Joaquin Light and Power Corporation, at 2200 and 440 volts. A 110 kv. transmission line extends from the new Kerckhoff Hydroelectric plant to the Sanger Substation, from which a 60 kv. line is built to Fresno. The Sanger Substation can also be supplied from the Midway and Bakersfield Steam Plants over a 110 kv. line. In emergency, power sufficient for the water works load can be obtained over 4 other distinct and separate routes. Several plants, particularly those in the downtown districts, are equipped with 2 incoming feeders and throw-over switches in case of failure of one line. Station 21 has been equipped with an automatic throw-over switch which automatically disconnects the plant from its normal operating line in case of trouble connecting same to its auxiliary source of supply. When the normal source of supply returns the automatic throw-over again operates connecting the station to its original bus. Other stations throughout the system will rapidly be furnished with this apparatus. All stations discharge directly into the mains, no reservoir capacity being provided.

Since the installation of the flow-meters and watt meters accurate

records have been kept and a study made of the monthly performance of each station with a view of reducing the performance of each of the 27 stations to a comparable basis. The following plan of procedure was finally adopted. A complete characteristic curve of each station was plotted from actual field test showing the usual performance curves, such as head capacity, efficiency capacity, and brake horse-power capacity, as well as draw-down capacity curves. At the end of each month the discharge for each station in terms of gallons per kilowatt hour for a 1 foot head is computed. Thus it will be seen that all variables such as, overall plant efficiency, and static head operated against are included, and the plants made comparable. Figure 4 shows graphically the results of this study for certain stations. These graphs are for the centrifugal type plants only, the study for the turbines not having been completed.

DISTRIBUTION SYSTEM

Up to and including July, 1923, the water company had installed 205 miles of distributing mains of all sizes, 65 per cent being between 2 and 5 inches in diameter, 32 per cent from 6 to 11 inches in diameter, and 3 per cent 12 to 16 inches in diameter. The 4- and 6-inch are principally National Tube Company's screw casing, with a small percentage of 6 inch cast iron, and some riveted steel, the balance being Matheson joint. The normal operating pressure in the principal mercantile district is kept between 40 and 45 pounds per square inch. The average length of pipe that will be put out of service by a single break in the mercantile district is about 925 feet. There are now in use 900 hydrants of the Cory and Fresno type. The latter are equipped with 6-inch branch in barrel with one $2\frac{1}{2}$ inch and one 4-inch outlet and a $4\frac{1}{4}$ -inch control valve located in a barrel just below the outlets. The average area served by hydrants in the principal mercantile district is approximately 54 thousand square feet. Up to and including September, 1923 there has been installed 17,200 services, which on the basis of 69,000 inhabitants reduces to approximately 4 people per service.

FINANCING EXTENSIONS

A very liberal policy is exercised in caring for new extensions. When applications come to the office for service in a district wherein mains have not been laid, a survey of the district is made and an

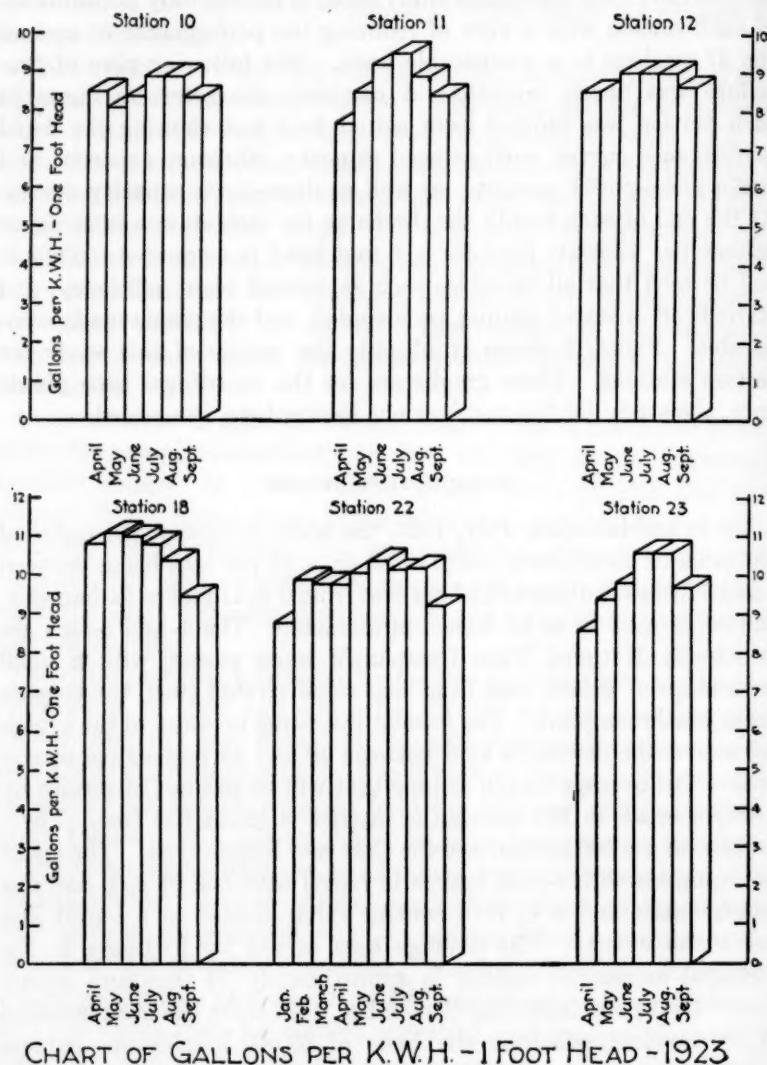


CHART OF GALLONS PER K.W.H. - 1 FOOT HEAD - 1923

FIG. 4

estimate prepared showing the cost of such extension. A contract is then drawn, stipulating that the realtor is to deposit with the company the estimated cost, the company to begin construction within two days. It is further provided that the water company will rebate the realtor to the full amount of the deposit in the following manner. For each house, store or building, connected to the system and occupied, the sum of \$68.00, until the balance of purchase price is paid, in addition thereto, a complete bill of sale to the water company is given. In other extensions, wherein application for service is made by a group of houses within the city, but not within reach of supply mains, a survey is made and estimate prepared showing length and size of main required, together with total cost. If the estimated revenue, based on \$18.00 per service per year will pay such cost of extension within a three-year period, the extension is warranted.

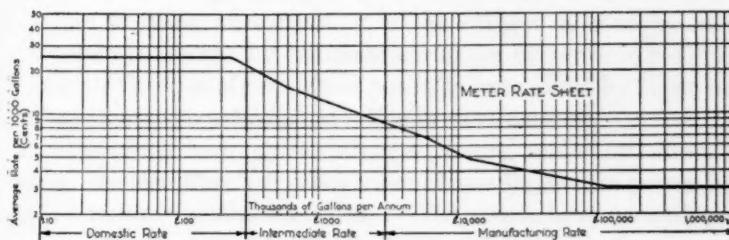


FIG. 5

METERING

The metering in Fresno has developed slowly. This is due primarily to the public spirited policy of the management, the desire being to encourage the use of lawn sprinkling and beautify the residential section. Of the 17,200 services there are only 1466 meters on the system or about $8\frac{1}{2}$ per cent. However, a metering program has been announced which includes business houses and apartment houses, excluding all residences. This, of course, accounts for the high consumption per capita which amounts to 15 million gallons daily or 221 gallons per capita expressed in terms of *average annual use*. The maximum consumption recorded during the last year occurred in August and reached a value of 32 million gallons per day for one day, or a consumption per capita of 464 gallons or practically twice the average annual use. During the winter months the total consumption will average about 10 million gallons per day, or 145

gallons per capita, which is about 65 per cent of the average annual use. These computations are based on total use of water supplied and measured at the pumps.

In conclusion, I submit the following statistics as of August, 1923:

Population of Fresno.....	69,000
Number of services on system.....	17,260
Inhabitants per service.....	4
Number of services per mile of main.....	84.2
Maximum use per service per month.....	55,269 gallons
Minimum use per service per month.....	14,091 gallons
Estimated average annual consumption per service per month.....	.26,117 gallons
Investment per service.....	105.00

923:

GUIDING PRINCIPLES OF PUBLIC SERVICE REGULATION¹

For many years the decisions of Public Utility Commissions have been published in Washington in "Public Utility Reports," and for the last three years the editor of that magazine, Henry G. Spurr, has given in each issue a review of all court and commission decisions on various features of rate making, valuation and the control of service to customers. A part of these reviews has now been published by the magazine in an 800-page volume on "Guiding Principles of Public Service Regulation," which differs from earlier treatises of this sort in being an exposition of the subject as fixed by law, by judicial decisions and by commission rulings, rather than a discussion of various theories of regulation not fully sanctioned by those having legal authority to establish practice in such matters.

Commissions have quite different powers, under our laws, from courts, because they are given more or less legislative power by the legislative body establishing them. The courts have no such power. The commissions investigate the business relations of utilities with their customers and study the economics of utility service in a way the courts do not. On the other hand, the courts have sole authority to decide questions concerning the existence, validity, force or effect of any law, and as the rulings of commissions are often equivalent to laws, such rulings must be reviewed by courts of final jurisdiction before they can be regarded as definitely fixed. In this volume both court decisions and commission rulings are cited, making it possible to ascertain quickly the exact status of many of the important phases of utility regulation.

The book outlines the history of regulation by these commissions; the extent and limitations of their control over utility business, financing, accounting, rates and service; and it points out in a special chapter the distinction between the powers of courts and commissions in such matters. It then outlines the different theories of rate making and explains the attitude of courts and commissions on the basis

¹ Book review, by J. M. Goodell, Civil Engineer, Upper Montclair, New Jersey.

of the return from investments in utilities, taking up in detail book cost, original cost and reproduction cost. The decisions and rulings on overhead expenses, financing expenses, good will, franchises, going value, cost of developing business, and cost of reproducing business are summarized and the book closes with chapters on water rights and intangible assets. A large index of cases cited is helpful in referring to original documents.

Utility regulation being in a state of constant change and the practice varying widely in different States, many of the older rulings cited are liable to be modified at an early date. Legislatures and commissions are slowly but steadily tending toward uniformity in utility regulation; therefore, only the specialist is a safe counsel in such matters. But the officers of a utility, public or private, who have studied this volume will be better able to help their counsel, and will receive more help from him, than those who remain uninformed of the basis, objects and methods of utility regulation, as we have it today.

George Chandler Whipple

Died November 27, 1924

Professor George Chandler Whipple, of Harvard University, passed away suddenly on the morning of November 27 at his home, 6 Berkeley Place, Cambridge, Mass. He was born at New Boston, New Hampshire, March 2, 1866, and was graduated in 1889 from the Department of Civil Engineering at the Massachusetts Institute of Technology. The field of sanitation, which was rapidly unfolding its possibilities at that time, claimed his services immediately upon graduation. From 1889-1897 he was in charge of the Chestnut Hill Laboratory of the Boston Waterworks, and from 1897-1904 had directed the work of the Mt. Prospect Laboratory of the Brooklyn and New York Water Department. Resigning his official duties in 1904, Mr. Whipple took up the private practice of sanitary engineering in New York City, and since that date he has been a member of the firm of Hazen and Whipple. Mr. Whipple has served on many important commissions having to do with the solution of sanitary problems.

In 1911 he was called to Harvard University and made Gordon McKay Professor of Sanitary Engineering which position he held at the time of his death. During the period when the Harvard Engineering School and the Massachusetts Institute of Technology were coöperating he was also Professor of Sanitary Engineering at the Institute.

Professor Whipple was one of the organizers of the School of Public Health of Harvard University and the Massachusetts Institute of Technology which was founded in 1913, and served as Secretary of the School until the new Harvard School of Public Health was established in 1922.

He held the position of Professor of Water Supply at the Brooklyn Polytechnic Institute from 1907-11. In 1914 Professor Whipple was appointed a member of the Public Health Council of the Massachusetts State Board of Health and was Chairman of the Committee on Sanitary Engineering until last year. He was also a member of the Massachusetts Homestead Commission.

From 1913 to 1916, he was a member of the Committee on Building Districts and Restrictions of New York City and from 1912 to 1916, Chairman of the Cambridge (Mass.) Sanitary Commission.

In 1917, he served as Major and Deputy Commissioner to Russia in the American Red Cross. In 1920 he was appointed Chief of the Department of Sanitation in the League of Red Cross Societies, Geneva, Switzerland, devoting considerable time to the study of typhus fever in Roumania.

From 1921 to 1923, he served as chairman of the Sub-Committee on Plumbing of the Building Code Committee of the United States Department of Commerce.

Professor Whipple was recently appointed a member of the general Directive Board of the Committee on Industrial Lighting of the National Research Council.

He has been President of the Boston Society of Civil Engineers, of the Brooklyn Engineers' Club, and of various other societies.

He was commissioned as Senior Sanitary Engineer with the grade of Assistant Surgeon-General, U. S. Public Health Reserve.

He was a member of The American Society of Civil Engineers, American Water Works Association, New England Water Works Association, Boston Society of Civil Engineers, American Society for Promotion of Engineering Education; Fellow, American Public Health Association; Fellow, American Academy of Arts and Sciences; Fellow, American Association for the Advancement of Science, Honorary Fellow, Royal Sanitary Institute, Member, Harvard Club of Boston and Boston City Club.

He was the author of many books and monographs, including *The Microscopy of Drinking Water*; *Typhoid Fever: Value of Pure Water*; *State Sanitation*; *Vital Statistics*; *Fresh Water Biology* (with Dr. Ward); *William Thompson Sedgwick, A Pioneer in Public Health* (With Professors C. E. A. Winslow and E. O. Jordan).

Funeral services for Professor George Chandler Whipple of Harvard University were held at Appleton Chapel, Cambridge, Mass., at 2.30 p.m. Sunday, November 30.

Although apparently in the best of health, Professor Whipple succumbed to a sudden heart attack and passed away without suffering.

Professor Whipple is survived by his wife, Mrs. Mary Rayner Whipple, a daughter, Marion (Mrs. Gerald M. Keith), and a son Joseph Rayner Whipple, who is a student at Bowdoin College.

SOCIETY AFFAIRS

IOWA SECTION

The tenth annual meeting of the Iowa Section opened in the Senate Chamber of the Old Capitol at the University of Iowa, on November 6, 1924. Chairman H. F. Blomquist called the meeting to order and introduced Dean Wm. G. Raymond, of the College of Applied Science of the University of Iowa who officially welcomed the Iowa Section on behalf of the University. Chairman Blomquist replied to Dean Raymond, thanking him and expressing appreciation of the courtesy of the University and Iowa City. (Forty-two present.)

The Section then began the Round Table Discussion. Topic 9, Stunts in the Boiler Room, was discussed by Charles R. Henderson, Homer V. Knouse, Dale L. Maffitt, Frank Lawlor, H. F. Blomquist, W. Luscombe and C. L. Ehrhart.

Topics nos. 1 and 2, Fire Prevention and Protection and Co-operation between the Fire Chief and the Water Works Superintendent, were discussed by Harry C. Corcoran, Thos. Maloney, H. F. Blomquist, L. L. Hezzlewood, C. L. Ehrhart, N. T. Veatch, Jr., H. V. Knouse and Wm. Molis.

Topic no. 3, The Proper Spacing of Fire Hydrants, was discussed by Harry Corcoran, H. F. Blomquist, Wm. Molis, Thos. Maloney and Homer Knouse.

The Section was invited by the Engineering Faculty of the University to attend its regular Thursday noon luncheon at Youde's Inn. About fifteen of the members accepted the invitation. Dr. Plant, of the College of Medicine, discussed the plans for the new Medical Building of the University.

The Section met at 1:50 p.m. in accordance with the schedule of the program at Room 318, New Chemistry Building, (number present 38). In the absence of the authors, the first three papers were read by the Secretary. These papers were:

An Inexpensive Autoclave for Small Laboratories, by E. E. Wolfe, Chemist, Board of Public Works, Hannibal, Mo.

Differentiation in the Colon Aerogenes Group of Bacteria by the Use of Chinic Acid, by B. H. Butcher, Iowa State College, Ames, Iowa.

A Note on the Test for Nitrates, by G. W. Burke, Iowa State College.

Clarence R. Knowles then read his paper entitled Treating Railroad Water Supplies in Iowa.

The paper was discussed by Edward Bartow, Royal H. Holbrook, R. E. Coughlan, N. T. Veatch, Jr. and L. B. Burt.

The paper by W. H. Kimball on the Improvement of the Settling Basins of the Davenport Water Company was read by Edward Bartow. Slides showing the basin were shown by Chas. R. Henderson.

The paper was discussed by C. R. Knowles, Lewis I. Birdsall, Edward Bartow, N. T. Veatch, Jr. and H. V. Knouse.

A. M. Williams' paper, Electrolytic Chlorine, was not read, but a substitute paper: Electrolytic Production of Chlorine by the Williams Cell for Water Sterilization, was read by A. L. Googins. The paper was discussed by H. F. Blomquist, Wm. Luscombe, Dale L. Maffitt and Royal H. Holbrook.

Chairman Blomquist then announced the following committees:

Nominating Committee: Chas. R. Henderson, Frank L. Lawlor and C. L. Ehrhardt.

Resolutions' Committee: E. L. Waterman, H. V. Knouse and Wm. Molis.

Auditing Committee: H. V. Pedersen and R. H. Holbrook.

The meeting was adjourned at 4:35 p.m., after which the Section was shown over the New Chemistry Building by Doctor Edward Bartow, Head of the Chemistry Department, University of Iowa.

At 6:00 p.m. the members of the Section met for an informal supper. (fifty-three present.)

At 7:30 p.m. the Section returned to Room 318 New Chemistry Building for the evening program. The following moving pictures were given.

The Construction and Operation of the Des Moines Municipal Water Works, by Dale L. Maffitt.

The Sanitary District of Chicago, by Robert Isham Randolph.

The Story of Water, by J. B. Spiegel, District Engineer, Hydraulic Resources Branch, U. S. Geological Survey, Ames, Iowa.

There were 115 present. The meeting adjourned at 9:05 p.m.

On the morning of November 7, N. T. Veatch, Jr. read his paper on The New Water Softening Plant of Topeka, Kansas. It was accompanied by slides. The paper was discussed by W. W. De Berard and H. F. Blomquist.

W. W. DeBerard then discussed the proposed manual of the American Water Works Association.

H. V. Pedersen read a paper on Water Purification Equipment in Small Towns, which was discussed by N. T. Veatch, Jr. and L. I. Birdsall.

The paper by Lafayette Higgins, Sr., was read by the Secretary and was discussed by W. W. DeBerard, H. V. Pedersen, Thos. B. Maloney, Jack J. Hinman, Jr., C. O. Bates, J. B. Spiegel, E. W. Bennison, Wm. Luscombe, N. T. Veatch, Jr., J. J. Myrtue, Harry Corcoran and J. W. McEvoy.

The meeting adjourned at 11:45 a.m.

The Section re-convened at 2 p.m. and listened to C. O. Bates, read his paper on the Protection of the Cedar River Drainage Basin; discussed by H. F. Blomquist, J. B. Spiegel, Roland S. Wallis, H. L. Stanley, George Bennett, Wm. Luscombe and H. V. Pedersen.

It was moved by H. V. Pedersen and seconded by William Molis: That the Iowa Section A. W. W. A. go on record as favoring the widest possible publicity in the state and elsewhere for Dr. Bates' paper. Motion carried. The Secretary was ordered to see to this matter.

The paper by J. B. Spiegel on Stream Measurements in Iowa was then read by the author.

Prof. Floyd A. Nagler, Assoc. Professor of Mechanics and Hydraulics of the University read his paper, Hydrologic Records.

The two foregoing papers were discussed together by the authors and H. F. Blomquist and W. E. Stanley.

The Iowa Section then went into its business session. Reading of the minutes was dispensed with on account of the earlier publication in the Journal of the Association.

The Resolutions' Committee by its Chairman, E. L. Waterman, brought in the following resolutions, which were adopted:

1. *Resolved:* That the Iowa Section of the American Water Works Association, in convention assembled, extend its thanks and appreciation to the University of Iowa and to President W. A. Jessup, for the use of rooms in the Old Capitol and the Chemistry Building as meeting places, and for the interest, help and coöperation given by individuals toward making the Tenth Annual meeting of the Section the success that it has been.

2. *Resolved*: That the Iowa Section of the American Water Works Association extend its special thanks to the Faculty of the University of Iowa, and in particular to Dean W. C. Raymond of the College of Applied Science, Dr. Edward Bartow of the Department of Chemistry and Dr. Don M. Griswold of the Department of Hygiene and Preventive Medicine, for their coöperation and for courtesies extended to the Section.

3. *Resolved*: That the Iowa Section of the American Water Works Association express its appreciation and extend its thanks to Chairman H. F. Blomquist, and other officers of the Section for their untiring efforts in furthering the welfare and conducting the business of the Section.

4. *Resolved*: That, since the activities of the Section are directed principally through the office of the Secretary of the Section and the responsibility for the carrying out of its business during the entire year as well as the success of the Annual Meeting rests upon the Secretary that the special thanks of the Section extended to Mr. Jack J. Hinman, Jr., for his untiring, devoted and unselfish service.

5. *Resolved*: That the Iowa Section of the American Water Works Association extend its thanks to E. E. Wolfe, R. H. Butcher, G. W. Burke, Clarence R. Knowles, W. H. Kimball, Dale L. Maffitt, Robert Isham Randolph, J. B. Spiegel, N. T. Veatch, Jr., W. W. DeBerard, H. V. Pedersen, Lafayette Higgins, Sr., Dr. C. O. Bates, Floyd A. Nagler, J. W. McEvoy, George T. Prince, E. W. Bennison, A. M. Williams, J. B. Trenchard, for the excellent papers which these gentlemen have contributed to this meeting.

6. *Resolved*: That the Iowa Section of the American Water Works Association express its regret at the untimely deaths of Edward H. Hart of Council Bluffs, Gen. Geo. W. Ball of Iowa City, Clinton S. Burns of Kansas City, Mo., and John H. Dunlap, formerly of Iowa City.

7. *Resolved*: That a copy of these resolutions be spread upon the minutes of the meeting and that copies of pertinent sections be sent to persons concerned.

WHEREAS God in his infinite wisdom has removed John H. Dunlap from our midst, and WHEREAS, John H. Dunlap was the moving spirit in the formation of the Iowa Section of the American Water Works Association, and for many years contributed freely of his time and energy in building up this section.

Therefore be it resolved: That this Section place in its records this expression of its appreciation of those qualities which made John H. Dunlap valued as an Educator, as an Engineer, and as a Citizen and that a copy of these resolution be spread upon the minutes of the Section.

Be it further resolved: That a copy of these resolutions be sent to the bereaved family.

EARLE L. WATERMAN,
WILLIAM MOLIS,
H. V. KNOUSE.

H. V. Pedersen brought in the report of the Auditing Committee which was accepted.

Thomas B. Maloney, chairman of the legislative committee,

brought in a progress report, recommending continuation of the committee and especial attention at the coming meeting of the General Assembly to the bill allowing assessment of water main extension to benefited property. The report was accepted.

Mr. Waterman advised the Section that the committee on Operation Records for Water Plants had no report to submit. It was moved by Thomas B. Maloney and seconded by H. V. Pedersen, that a new committee be appointed and that its function be extended to include additional water works statistics. Carried.

The nominating Committee, by Frank Lawlor, brought in the following ticket:

For Chairman, Dr. Max Levine; for Vice Chairman, H. V. Knouse; for Director, N. T. Veatch, Jr.; for Director, J. W. McEvoy.

Their election was moved by Thos. B. Maloney, seconded by F. L. Hezzelwood. Carried.

J. W. McEvoy invited the Section to hold its next meeting at Dubuque, Iowa, and H. V. Pedersen, invited the Section to meet in Des Moines, Iowa. Choice was left to the Executive Committee. The meeting adjourned at 5 p.m.

At 6:30 p.m. the members of the Section were entertained with an excellent dinner at Youde's Inn by the agents of the manufacturers.

On the morning of November 8, J. W. McEvoy read his paper on Dubuque's New Air Lift Pumping Plant; discussed by Frank Lawlor, H. F. Blomquist, Harry Corcoran, E. L. Waterman, Geo. T. Prince, G. C. Baker and Jack J. Hinman, Jr.

George T. Prince read a paper on Improving the Water Supply of Winner, So. Dakota. It was discussed by Frank Lawlor.

E. W. Bennison read his paper entitled Methods of Developing Underground Water Supplies; discussed by J. W. McEvoy, Geo. T. Prince, Harry Corcoran and Frank Lawlor.

The last paper of the meeting, The Development of Internal Combustion Engines for Water Works Use, was read by J. B. Trenchard of the Fairbanks Morse Co., of Des Moines, Iowa; discussed by E. L. Waterman, Geo. T. Prince and H. F. Blomquist.

A vote of thanks to the Manufacturers' Agents for their courtesies was unanimously carried.

Frank Lawlor made a final plea for enlistment of members and manufacturers agents in increasing the membership of the Section. The secretary explained what had been done from his office and asked that the members assist in securing new members, particularly among the waterworks men of the smaller communities.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Spavinaw Water Supply Project for Tulsa, Oklahoma. ANON. Eng. News-Record, 92: 816-18, 1924. Dam 3500 feet long and 55 feet high is being built on Spavinaw creek to impound 18,000 m.g. Water will be carried by gravity from impounding reservoir through 60-inch conduit 53 miles long to 500 m.g. storage reservoir 4 miles from Tulsa. It will then be pumped up 275 feet to 10 m.g. high service reservoir from which it will flow to city. Capacity will be 25 m.g.d.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Additional City Pipe Conduits of the Catskill Aqueduct. WALTER E. SPEAR. Eng. News-Record, 92: 838-41, 1924. Large steel conduits are being laid to deliver Catskill water to Brooklyn, Queens, and Richmond Boroughs.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Marshfield, Wis., Gets Well Supply After 25 Years Search. ANON. Eng. News-Record, 92: 843, 1924. Five 30-inch wells, with capacity of 3 m.g.d., were drilled.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Venturi Feed Controller for Dry Chemical Feed Devices. E. S. SMITH, JR. and C. G. RICHARDSON. Eng. News-Record, 92: 844, 1924. Venturi speed controller for chemical dry feed machines at Parsons, Kansas, filtration plant is described.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Wells for Water Supply of London, Ont. ANON. Eng. News-Record, 92: 845, 1924. Additional well water supply of 4 m.g.d. is proposed.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Early Results of Clarifier at Newark, Ohio. ANON. Eng. News-Record, 92: 847, 1924. Continuous sludge removal at 6 m.g.d. water softening and purification plant is working satisfactorily.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Water Works Improvements at Wheeling, West Virginia. L. F. LABOON. Eng. News-Record, 92: 848-50, 1924. New 20 m.g.d. filter plant for Wheeling, West Virginia, is described.—*Frank Bachmann.* (Courtesy Chem. Abst.)

Laying Large Water Main Through Swamps in New Orleans. JOHN T. EASTWOOD. Eng. News-Record, 92: 854-56, 1924. Difficulties encountered and overcome in laying 6 miles of large size cast iron water main are described.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Small Water Purification Plant for Jacksonville, Texas. H. N. ROBERTS. Eng. News-Record, 92: 859, 1924. Dam for 180 m.g. impounding reservoir was constructed. Water is carried by gravity through 12-inch cast iron main to 1 m.g.d. filtration plant.—*Frank Bachmann. (Courtesy Chem. Abst.)*

New Spring Water Supply and Covered Reservoir, Batavia, D.E.I. C. ORTT. Eng. News-Record, 92: 860, 1924. Springs on lower slopes of Mount Salak, 32 miles from Batavia, Dutch East Indies, furnish supply. Pipe lines, equalizing reservoir, and distribution mains are described.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Double Filtration of Water in Europe. GEO. W. FULLER. Eng. News-Record, 92: 205, 1924. Short review of filtration practice at Zürich, Berlin, Hamburg, London, and Edinburgh.—*Frank Bachmann. (Courtesy Chem. Abst.)*

New Sources of Water Supply for Philadelphia Recommended. ANON. Eng. News-Record, 92: 290, 1924. Delaware River at Torresdale has been more dangerous to health the majority of the time than Schuylkill River. During past year about one third of the Schuylkill samples tested showed Bact. coli in 1:1000 dilutions.—*Frank Bachmann. (Courtesy Chem. Abst.)*

London Water Works Enlargements. ANON. Eng. News-Record, 92: 368, 1924. Included are new pumping units, large reservoir, various intakes and conduits, and double filtration plants.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Serious Typhoid Epidemic Caused by Drain Sewer Connection. ANON. Eng. News-Record, 92: 409, 1924. Raw sewage pumped into water supply main at Santa Ana, Calif., resulted in 230 typhoid cases.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Foul Tastes in Cleveland Water Again Caused by Phenol. J. W. ELLMS. Eng. News-Record, 92: 453, 1924. By-product coke oven wastes from Cuyahoga River cause chlorophenolic tastes in water. Tremendous increases in number of bacteria present were noted at same time.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Sanitary Defects of a Well Water Supply. ANON. Eng. News-Record, 92: 489, 1924. Correctable structural defects in water supply system are called sanitary defects in tentative revision of present Treasury Department standards. List of such sanitary defects is given.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Sand Bed Studies at Montebello Water Filters—I. JOHN R. BAYLIS. Eng. News-Record, 92: 517-22, 1924. Gelatinous coating found on sand grains affects efficiencies of filter. Thin gelatinous coating is desirable. Most trouble from cracks and clogged places in filter beds, where proper size sand has been used and there is even distribution of wash water, may be due to thick gelatinous coating on sand grains. To eliminate thick coating, water is forced into beds through jets under pressure. Sand that had been settling 6 per cent of its depth settled only 1.5 per cent after most of coating was washed off with jet. Uniform round sand of about 0.6 mm. is recommended for water like that handled at Montebello plant.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Board Reports on Detroit's Water Supply Needs. ANON. Eng. News-Record, 92: 466, 1924. Committee of consulting engineers appointed by Detroit Board of Water Commissioners recommend immediate development of new 300 m.g.d. supply.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Study of Flocculation Phenomenon with Microscope. JOHN R. BAYLIS. Eng. News-Record, 92: 768-9, 1924. Studies show that over-coagulation produces an easily broken floc that will pass rapid sand filter beds; that suspended matter adds toughness to floc; and that rapid mixing of alum with water is desirable.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Sand Bed Studies at Montebello Water Filters—II. Eng. News-Record, 92: 563-68, 1924. Discussion by H. E. BABBIT, PHILLIP BURGESS, C. M. DAILY, W. DONALDSON, J. W. ELLMS, J. B. HAWLEY, W. F. LANGEIER, DABNEY, H. MAURY, LEONARD METCALF and F. H. WARING of John R. Baylis's article in Engr. News-Record 92: 517-22, 1924 and reply to discussion by Mr. BAYLIS.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Cross Connections and Typhoid Again. ANON. Eng. News-Record, 92: 349, 1924. Cross connections between Pennsylvania Railroad's private supply and city water main of Fort Wayne permitted polluted river water to enter main which resulted in 150 cases of typhoid and 32 deaths. Rule adopted by Indiana State Board of Health prohibits such connections after June 1, 1924.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Locating Water Borne Typhoid Infection at Brenham, Texas. GEORGE W. COLES. Eng. News-Record, 92: 947, 1924. Brick lined sunken cistern, used as water supply reservoir, was being polluted by a nearby creek.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Startling Water-Works Figures from Chicago. ANON. Eng. News-Record, 92: 947, 1924. During 1923, 800 m.g.d. of water were pumped, 151,021 tons of coal burned, and 366 tons of chlorine used, at Chicago pumping stations. Only 10 per cent of services are metered.—*Frank Bachmann. (Courtesy Chem. Abst.)*

Recommends Storage Reservoir for Flint. ANON. Eng. News-Record, 92: 805, 1924. Construction of dam above Genesee on Flint River to provide Flint with 1856 m.g. storage reservoir is recommended.—*Frank Bachmann.* (Courtesy *Chem. Abst.*)

Court Holds Water Company Liable for Typhoid Death. G. DOUGLAS ANDREWS. Eng. News-Record, 92: 814, 1924. Widow of typhoid decedent was awarded \$2000 by jury at Walnutport, Pa.—*Frank Bachmann.* (Courtesy *Chem. Abst.*)

Solubility of Portland Cement in Weathering Agents. H. K. BENSON, J. S. HERRICK, T. MATSUMATE. Ind. & Engr. Chem., 16: 10, 1063, October, 1924.

Portland Cement contains, theoretically, approximately:

35 per cent tri-calcium silicate ($3 \text{ CaO} \cdot \text{SiO}_2$)

36 per cent di-calcium silicate ($2 \text{ CaO} \cdot \text{SiO}_2$)

18 per cent tri-calcium aluminate ($3 \text{ CaO} \cdot \text{Al}_2\text{O}_3$)

When water is added, hydrolysis of tri-calcium silicate results in liberation of alkali. Theoretically it is possible to liberate and dissolve from dry cement approximately 22.5 per cent of its weight in form of calcium hydroxide ($\text{Ca}(\text{OH})_2$). Experiments confirm this. Water which has stood in contact with excess cement for some hours will have calcium hydroxide content identical with that of saturated lime water at same temperature. Solubility of hardened cement test pats, two or more months old and ground to equal fineness was practically that of fresh dry cement. Presence of carbon-dioxide caused increased solubility of hard cement, but to considerably less degree than leafy or bark extracts. Water containing Douglas fir needle extract (0.0045 N. acidity) dissolved a maximum of 62 per cent of the hardened cement resulting in approximately 95 per cent disintegration of its molecular structure.—*Linn H. Enslow.*

Manufacture of Alkali Chlorine Products—The Canadian Salt Company's Process. D. A. PRITCHARD and G. E. GALLOP. Ind. & Eng. Chem., 16: 10, 1086, October, 1924. Illustrated description covering process of electrolytic production of sodium-hydroxide, liquid chlorine, and bleaching powder. Starting with geology of salt deposits and continuing through to finished products f.o.b. cars, each process is carefully outlined and explained, aided by photographs of plant equipment.—*Linn H. Enslow.*

Overloading of Water Purification Plants. ANON. Amer. City, 31: 18-21, 1924. Stated to be abstract of Report of Committee 3 of A. W. W. A. Discusses factors affecting performance of purification processes and offers tentative limits of loading for coagulation and sedimentation, filtration and disinfection. Recommendations made as to essential data and record forms. (Note by ABSTRACTOR. At New York meeting of A. W. W. A. Committee 3 declined to make report. Material in question represents only contribution to work of committee by one of its members, offered for purpose of discussion.)—*W. Donaldson.*

Stream Pollution by Industrial Wastes and Its Control. J. FREDERICK JACKSON. Amer. City, 31: 23-26, 1924. Paper before New England Health Institute: traces development of stream pollution problems both in this country and abroad. Lack of public appreciation of seriousness of problem and selfishness of manufacturers in opposing all restraints are named as reasons for slow progress in abatement. Effects of various classes of trade waste are given. Discusses method of governmental control such as Rivers Boards of Great Britain and Germany, and various state agencies in this country.—*W. Donaldson.*

Hard Water and Water Softening. E. F. BADGER. Amer. City, 33: 33-35. Publication of Michigan State Board of Health states concisely the generally accepted facts as to origin, effects and cost of hard water, and the methods and costs of softening. Hardness of Michigan waters are generally temporary, requiring little soda-ash for softening.—*W. Donaldson.*

The Modern Water Works of Buenos Aires, Argentina. J. W. LEDOUX. Amer. City, 31: 43, 1924. The South American City has 1924 population of 1,929,000 and estimated water consumption of 140 m.g.d. Supply is from Rio de la Plata 80 miles wide at intake, tidal, though fresh and turbid. Two separate works serve the city. Older Recoleta plant has slow sand filters. Palermo plant has rapid sand filters in 8 m.g.d. units, and some slow sand filters being converted to rapid type. There is a plant for manufacturing sulphate of alumina. City being flat, rectangular steel tanks, 12 feet deep, holding 1.5 m.g., and elevated 200 to 230 feet, are used for pressure distribution except for tall buildings. Water Works buildings and grounds are very attractive in comparison with average American works. Employees of the two stations number 2700. Laboratory facilities are very complete, and staff includes large number of chemists, biologists and physicists.—*W. Donaldson.*

How Polluted Water May Be Made Safe. ANON. Amer. City, 31: 44, 1924. New York State Department of Health broadcasts weekly from Station WGY at Schenectady. One of weekly talks by Commissioner gave timely advice regarding drinking water.—*W. Donaldson.*

Terre Haute's Enviable Record. ANON. Amer. City, 31: 47, 1924. Water works superintendent mails to each consumer blueprint showing decline in typhoid rate, facts as to water works, and contemplated improvements.—*W. Donaldson.*

New York Protects Aqueduct Water with Chlorine. ANON. Amer. City, 31: 44, 1924. Supplementary chlorination is being installed at 135th St. gate house to offset possible pollution of old Croton aqueduct.—*W. Donaldson.*

City Water Works Reports Surplus for the First Time. ANON. Amer. City, 31: 51, 1924. South Bend, Ind., in annual report for 1923, shows water

works surplus for first time in its history. Improvements are planned to include modern pump station. Supply of 12 m.g.d. is derived from 24 wells, 12 inches diameter and 140 feet deep.—*W. Donaldson.*

Variations in Daily Consumption Throughout the Year. ANON. Amer. City, 31: 51, 1924. Table gives by months per capita consumption during 1923 of various cities and towns of Metropolitan Water District of Boston.—*W. Donaldson.*

An Emergency Pumping Unit for a Small Water Works. E. S. TYNER. Amer. City, 31: 55-56, 1924. Plant City, Fla., with 650 services, all metered, gets its supply normally from 12 inch well, 630 feet deep. Duplicate triplex pumps, driven by oil engines, deliver into standpipe and mains. For reserve equipment, an older 8-inch diameter well was enlarged to 10 inches in upper 60 feet section to accommodate a vertical shaft deep well centrifugal pump. Drive is 50 hp slip ring motor. Pump delivers 650 g.p.m. against 50 pounds pressure with power consumption of 40 kwh. Expense of electric current compared with crude oil does not permit continuous service with new pump.—*W. Donaldson.*

Water Works Improvements in Denver. ANON. Amer. City, 31: 35, 1924. Ashland reservoir being relined at cost of \$100,000. Contracts for 10 miles of 66 inch Douglas fir stave pipe have been let for \$761,000; also contract for 20,330 feet 54-inch reinforced concrete conduit at cost of \$417,000. Latter will carry 50 m.g.d. and will replace two old wood lines. Nearly one million dollars has been spent in new equipment.—*W. Donaldson.*

Report King Institute Preventive Medicine, Guindy, India, 1922-23. Experiments carried out at the Guindy Experimental filters, between 1921-1923. Major J. CUNNINGHAM. Research work undertaken to determine future water purification policy in Madras Province, India. Rapid sand filtration followed by chlorination is proposed. Sand filters containing 12 inches of fine sand were used in experiments, and rates of 4, 8, 12, and 16 vertical inches per hour. Raw water is subject to considerable physical and bacteriological seasonal variations. With an initially clear water, rate of 16 inches at end of 11 days reduced the total yield in gallons of filtered water by about 30 per cent as compared with 8 and 12 inch rates, although bacterial results were satisfactory. Experiments at 16 inch rate were therefore discontinued. Under varying physical conditions, 8 inch rate was regarded as satisfactory; filters running 33 days, bacterial reduction being 64 per cent and effluent suitable for chemical treatment. At 12 inch rate, filters ran 17-18 days and showed good bacterial efficiency. Concluded that rapid filtration through shallow layer of sand, satisfactorily clarified Adyar River Water even at greatest turbidity. Filters yielded satisfactory results as regards clarification after third day. Breaks in film occurred and were ascribed to action of insects, air-bubbles and algal growths. With rates of filtration more rapid than 4 inches, filters worked for comparatively shorter periods. Experiments indicated that 12 inches would be limit in practice. Actual figures were:

RATE OF FLOW inches	MAXIMUM NUMBER OF DAYS FILTERS WORKED	TOTAL YIELD <i>imp. gals.</i>
4	91	365,000
8	29	232,800
12	18	228,000
16	10	162,100

Bacterial purification by rapid filtration although not so good as with slow sand, is satisfactory and compares not unfavorably with results of Muffassal slow sand filters. Brief experiments were also made with slow sand filters on the question of intermittent and continuous filtration. Intermittent filtration was found most unsatisfactory, frequent breaks in surface film occurring, resulting in raw water passing into filtered water chamber. Intermittent filtration is characterized as wasteful and unsafe.—*Norman J. Howard.*

Impure Waters for Mixing Concrete. DUFF A. ABRAMS. Can. Eng., 46: 25, June, 1924. Tests made using 68 different kinds of waters, including sea, alkali, bog, mine, and mineral waters, waters containing sewage, industrial wastes, and water containing common salt. Fresh water, including distilled water, was used for comparative tests. Contrary to accepted opinion, majority of samples gave good results, claimed to be due to fact that most water samples contained injurious substances only in small quantities. Acid waters, lime soak from tannery, refuse from plant factory, mineral water from Colorado, and waters containing over 5 per cent of common salt gave strengths below 85 per cent. Neither odor nor color is any indication of suitability of water. Bog waters gave good results, strength being seldom below 90 per cent. Sulfate waters produced little ill effect until an SO_4 concentration of 1 per cent was reached, when reduction in strength of 10 per cent was recorded. Water containing 3.5 per cent sodium chloride compared favorably with fresh water, but is not recommended, particularly in tropics, on account of danger of corrosion of reinforcement. Great Salt Lake water, containing 20 per cent sodium chloride, was unsatisfactory, giving strength 65.77 per cent. Use of common salt for lowering freezing point of mixing water during cold weather should not be permitted. 5 per cent salt lowers freezing point 6°F., but reduces strength about 30 per cent. Impure waters gave about same strength-ratios regardless of the mix used, over usual range in mixtures, 1-4 to 1-5; strength increased 1 per cent for each 1 per cent additional cement. Increasing quantity of mixing water reduced strength of concrete. Effect of impure waters was in general independent of consistency of concrete.—*N. J. Howard.*

Planning Municipal Water Works System. Bulletin of Cast Iron Pipe Bureau. Can. Eng., 46: 26, June, 1924. Site of plant important. Service of competent engineer must be secured. Survey of source should be undertaken by public health officials. Consideration should be given to hardness

of proposed supply. Pumping plant, storage, and distribution system must be figured for normal increase of population. All domestic and industrial services should be metered. Hydrants should be placed in most suitable positions and have 6-inch connections to street mains so as to cut down friction loss. These should be inspected, tested and flushed frequently in spring and fall. Waterworks records should be kept up to date, particular attention being given to additions and alterations. Superintendent should be competent, experienced in water purification, independent of political factions, and well paid.—*N. J. Howard.*

Modern Water Control Apparatus. F. JOHNSTONE-TAYLOR. Can. Eng., 47: 13 and 14, Sept., 1924. Illustrated article describing sluices, gates, valves, used in large waterworks undertakings. Chart is given for calculating power required for lifting gates.—*N. J. Howard.*

Mechanical Filtration Plant Levis, Quebec. EDOUARD HAMEL. Can. Eng., 47: 15 Oct., 1924. Illustrated description of the new plant at Levis.—*N. J. Howard.*

Disposal of Industrial Wastes in United States. HARRISON P. EDDY. Can Eng., 47: 15, October, 1924. Paper presented at International conference, London, Eng., discussing industrial wastes and their effect on stream pollution. Detailed classification of wastes, treatment, and Government regulations.—*N. J. Howard.*

Meters Save Water in London, Ont. E. V. BUCHANAN. Can. Eng., 47: 15, October, 1924. Water consumption 90 gals. per capita; consumption per meter for residential consumers averages only 50 gals. Pitometer survey showed large residential wastage. Result of installing additional 4,000 meters showed average saving of 185 imperial gals. per meter per day.—*N. J. Howard.*

Manufacture of Liquid Chlorine. CANADIAN SALT Co. Can. Eng., 47: 15, October, 1924. Description and photographs of plant used in manufacture of liquid chlorine.—*N. J. Howard.*

Duplicate Waterworks System Toronto, Ont. Extract report R. C. HARRIS. Can. Eng., 47: 16, October, 1924. Proposed duplicate plant for Toronto to cost 14 million dollars. Discussion of various sites in and around Toronto. Building of additional intake off Toronto Island regarded as unjustifiable in light of past experience.—*N. J. Howard.*

Report on Water Filtration System at Ottawa, Canada. A. F. MACULLUM. Can. Eng., 47: 18, October, 1924. Scheme recommends rapid sand filtration system located on Lemieux Island, to filter 30 mil. imp. gals. daily at cost of \$1,050,000. Yearly operation and maintenance costs estimated at \$63,000 excluding interest on capital expenditure. Per capita consumption 160 imp. gals.: only 5 per cent of 27,700 services metered. Report recom-

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mends metering all services at additional cost of \$425,000. Present treatment of city water costs \$16,000 per annum and consists of chlorine application at rate of 7.6 pounds per mil. imp. gals.—*N. J. Howard.*

Chlorinating Bathing Water. W. P. BAKER and P. E. McNAB. Can. Eng., 47: 20, November, 1924. Reprint Jour. Amer. Assoc. for Promoting Hygiene and Public Baths. Calcium hypochlorite used for disinfecting. Water contains at all time excess of free chlorine ranging between 0.2 and 0.5 p.p.m. Orthotolidin used for testing purposes. Epidemiological rôle played by swimming pools: said to transmit intestinal, respiratory, venereal, conjunctival, and cutaneous infections. Motor boat used in conjunction with a W. & T. pedestal machine for treating swimming pool waters. Water in basin through Potomac River showed bacterial reduction from 175,000 to 500 per cubic centimeter. Anaërobic lactose fermenters were not destroyed. Claimed that 90 per cent of bathers clear their throats and nostrils and expectorate into water repeatedly. Cost of treatment at Washington public bathing beach less than \$50 daily, equal to cost per bather of 2 cents. Treatment of swimming pool water represents cheap insurance against water borne epidemics.—*N. J. Howard.*

The Rapid Corrosion of Condenser Tubes. GUY D. BENGOUGH. Engineer, 136: 7-10, 1923. From Chem. Abst., 17: 3670, November 20, 1923. Corrosion of condenser tubes due to presence of entangled air in circulating water investigated. Sea water as employed for condensing always contains small amount of air as small bubbles. Corrosion by such water is more rapid when the entangled air is in state of fine subdivision. Corroded surface is remarkably free from corrosion product. Apparently a protecting scale is penetrated and removed by bubbles. Hydrogen sulfide in condensing water is harmful.—*R. E. Thompson.*

Anaërobies from Water Samples. P. D. MEADER and E. A. BLISS. Am. J. Hyg., 3: 394-400, 1923. From Chem. Abst., 17: 3687, November 20, 1923. Experiments were made with 76 tubes of lactose broth cultures from raw and treated waters which had yielded gas but had failed to give other tests for *B. coli*. Sixteen of the tubes contained anaërobies, but only two of these fermented lactose with production of gas; from which it is concluded that number of anaërobies which give false presumptive tests for *B. coli* is not so great as generally supposed. Presence of anaërobies seemed to bear no relationship to total bacterial count.—*R. E. Thompson.*

Changes in the Stability and Potential of Cell Suspensions. I. The Stability and Potential of *B. Coli*. A. H. EGGERTH. J. Gen. Physiol., 6: 63-71, 1923. From Chem. Abst., 17: 3689, November 20, 1923. Stability and potential of *B. coli* depend upon strain used, medium, previous treatment, and length of time in medium. With acid reaction, negative charge is diminished and, with some strains, positive charge acquired. When acid-treated bacteria washed at neutral or alkaline reaction, original potential not restored, but zone of flocculation moved toward alkaline side.—*R. E. Thompson.*

Action of Natural Waters on Lead. J. C. THRESH. *Analyst*, 47: 459-68, 500-5, 1922. From *Chem. Abst.*, 17: 3733, November 20, 1923. Pure water has no action on lead; but, if oxygen is present, oxidation takes place, continuing until oxygen is used up. In water of pH 7, lead may occur in molecular solution and be capable of accurate estimation; but, with greater pH, a portion at least of the lead is in colloidal solution. Silicic acid and silicates have marked property of retarding oxidation and preventing lead from passing into solution. Alkali silicates are several times more powerful than silicic acid and should become of great importance in practice.—*R. E. Thompson*.

Recent Work on the Problem of Waste Waters. B. SIMMERSBACH. *Dinglers polytech. J.*, 338: 105-9, 117-20, 131-5, 1923. From *Chem. Abst.*, 17: 3732, November 20, 1923. Review and discussion.—*R. E. Thompson*.

Water Purification. L. T. GUY. *Commonwealth Eng.*, 11: 35-7, 1923. From *Chem. Abst.*, 17: 3732, November 20, 1923. Methods of water treatment and growing need for water treatment in Australia discussed.—*R. E. Thompson*.

Some Observations on Mixtures of Sea Water and Soft Water. A. MASSINK. *Rec. Trav. chim.*, 42: 605-8, 1923. From *Chem. Abst.*, 17: 3732. November 20, 1923. Method of Precht applied to determine relative proportions in mixtures of sea and fresh waters. Results were satisfactory.—*R. E. Thompson*.

Comparative Study of Some Methods of Chemical Analysis of Humus in Soils. V. AGAFONOFF. *Compt. rend.*, 177: 404-6, 1923. From *Chem. Abst.*, 17: 3735, November 20, 1923. Chlorine Index varied directly with humus content, giving approximate measure of latter.—*R. E. Thompson*.

The Nature of the Neutral Red Reaction in Bacterial Cultures. I. HANS GEILINGER and CARL SCHWEIZER. *Biochem. Z.*, 138: 72-91; *Mitt. Lebensm. Hyg.*, 14: 241-9, 1923. From *Chem. Abst.*, 17: 3689, November 20, 1923. Substance responsible for reduction of neutral red in Bornand's reaction originates in meat extract, not in agar. Presence of agar improves reaction. **The Conditions for the Production of the Biochemical Neutral Red Reaction.** *Ibid.*, 92-118. Canary-yellow color with green fluorescence is a reduction product. Excess oxygen may cause this to revert to original dye. Reaction is of value in detecting many polluting organisms other than *B. coli*; green fluorescence is the criterion; gas evolution is of aid in detecting *B. coli* only.—*R. E. Thompson*.

Iodine in Natural Waters in Relation to Goiter. J. F. McCLENDON. *Proc. Am. Soc. Biol. Chem.*, *J. Biol. Chem.*, 55: 16-17, 1923. From *Chem. Abst.*, 17: 3713, November 20, 1923. River water represents leachings from soils. Iodine averages 0.8 per billion and goiter 8 per 1000 troops in Mississippi River system, Minnesota. In Missouri, iodine content is increased to 2,

and goiter reduced to 4. Rats fed potassium iodide for two generations had thyroids averaging half the weight of rats which received no iodine.—*R. E. Thompson.*

Lime in Water Treatment Plants. W. D. COLLINS. *Rock Products*, 27: 18, 55-7, 1923. From *Chem. Abst.*, 17: 3732, November 20, 1923. Discussion of widening field for use of high-calcium lime in municipal, industrial, and railroad plants for softening, and for removing harmful bacteria. A "hardness of water" map of U. S. is included.—*R. E. Thompson.*

The Practical Application of Flue Gas Analysis. C. F. WADE. *Fuel*, 2: 202-3, 1923. From *Chem. Abst.*, 17: 3773, November 20, 1923. Three methods of determining carbon dioxide discussed: (1) intermittent "snap" test; (2) average sample over period; and (3) continuous automatic record. (1) Is useful in locating cause of low carbon dioxide indicated by (3)—by test holes at successive passes, air leakage can be detected; (2) is of doubtful value; (3) should be used for determining efficiency of combustion, presence of excess air, and percentage of carbon dioxide per unit weight of fuel consumed, rather than percentage of carbon dioxide in waste gases.—*R. E. Thompson.*

Researches on Vertical Retort Tars. I. Phenolic Constituents. G. S. CURRY. *Chem. and Ind.*, 42: 379-86T, 1923. From *Chem. Abst.*, 17: 3777, November 20, 1923. Cause of coloration of river water by waste from gas-works found to be presence of polyhydric phenols (principally catechol) in vertical-retort ammonia liquor. Colored emulsions obtained when disinfectants made from vertical-retort tar oils are added to water are due to presence of catechol in the oils.—*R. E. Thompson.*

Nature of Lubrication in Engineering Practice. T. E. STANTON. *J. Inst. Petroleum Tech.*, 9: 260-73, 1923. From *Chem. Abst.*, 17: 3784, November 20, 1923. Lubrication of reciprocating motions may be taken as boundary lubrication, hence use of fatty acids will effect improvement in efficiency. With steady relative motion, it would be possible, by use of suitable lubricant and correctly proportioned surfaces, to set up condition of film lubrication of Reynolds type with all advantages this system affords. With reciprocating motion liberal grooving to give oil access to all parts of bearing surfaces is necessary for efficient boundary lubrication.—*R. E. Thompson.*

Steam Turbines and Their Lubrication. F. A. HOFF. *Oil News*, 11: 17, 15, 1923. From *Chem. Abst.*, 17: 3784, November 20, 1923. General discussion of desired properties of turbine oils.—*R. E. Thompson.*

Deterioration of Turbine Oils in Use. ALEX. DUCKHAM and S. E. BOWREY. *Engineering*, 116: 353, 1923. From *Chem. Abst.*, 17: 3784, November 20, 1923. Importance of chemical character of constituents of crude oil, for production of turbine oils resistant to oxidation under severe conditions, is emphasized.—*R. E. Thompson.*

A New Calcium Chloride Sprinkler System. R. P. SIMS. Quart. Nat. Fire Protection Assoc., 16: 267-75, 1923. From Chem. Abst., 17: 3791, November 20, 1923. Detailed description of combination calcium chloride—water sprinkler system in Cold Storage Warehouse of Montreal Harbor Commission. No corrosion difficulty has been experienced. Calcium chloride solution is discharged from tank in roof until predetermined level is reached, when city supply is automatically turned into pipes. Alarms are provided to operate when rate of temperature rise in any cold storage room exceeds 15°F. per minute. Calcium chloride and dry-pipe systems are compared.—*R. E. Thompson.*

Jointing a Metropolitan Water Main. Municipal Engineering, 73: 170, February 14, 1924. Installation of 36-inch main, using victaulic joints, overcoming two-fold difficulty of very restricted space and curving line, described briefly. Average time for fitting joints was 20 minutes, compared with 2½-3 hours for spigot and socket. Added advantage is extreme ease with which any pipe can be removed without disturbing remainder of system. Will maintain vacuum of 28 inches of mercury, and resist inflow of liquid against considerable pressure. Other installations outlined, including 16-inch sewer across valley at Dartford, in which average time per joint was 5 minutes; the line being leak-tight immediately without further attention.—*R. E. Thompson.*

The Chlorination of Water Supplies, Results of Seven Years' Experience. A. J. J. VANDEVELDE. Bull. soc. chim. Belg., 30: 119-24, 1921. From Chem. Abst., 16: 3519, October 20, 1922. Scheldt water supplying Ghent is treated with 1.5 p.p.m. chlorine (as bleaching powder) and 0.33-1.0 kg. lime per cubic meter; excess lime is precipitated with carbon dioxide; and an additional 1-1.5 p.p.m. of chlorine is added after filtration. Bacteria are greatly reduced and *B. coli* completely eliminated, but aftergrowths occur. Odor and flavor of water are disagreeable, and constant control of process is necessary. Lime alone not satisfactory.—*R. E. Thompson.*

The Determination of Nitrate in Drinking Water by Mayrhofer's Method. A. REUSS. Z. Nahr. Genussm., 43: 174-83, 1922; J. Chem. Soc., 122: II, 454-5, 1922. From Chem. Abst., 16: 3520, October 20, 1922. Presence of sodium chloride increases consumption of indigo in indigo titration. When sample contains less chloride than equivalent of 1.0 g. sodium chloride per liter, sodium chloride should be added to give this concentration. Results also vitiated by presence of slightest visible sediment in indigo solution, which should be filtered through asbestos without suction until free from suspension when examined under lens. Details of preparation of indigo solution according to Lehmann given in original.—*R. E. Thompson.*

Theoretical Discussion of the Separation Phenomenon which occur in the Decarbonation of Water. W. DIETRICH. Wochschr. Brauerei, 38: 226-8, 234-5, 1921; Chimie et Industrie, 8: 85, 1922. From Chem. Abst., 16: 3520, October 20, 1922. Detailed discussion in original of crystallization and con-

densation phenomena which occur in decarbonation of alkaline water by means of lime, in light of work of von Weimarn. Separation of carbonates can easily be followed, either as colloidal turbidity, or as large crystalline flakes, by means of formulas deduced.—*R. E. Thompson.*

Feed Water Treated at Cost of 9.8 Cents per 1,000 Gallons. ANON. *Elec. World*, 80: 180-1, 1922. From *Chem. Abst.*, 16: 3520, October 20, 1922. Methods of treatment briefly discussed. Continuous treating process usually employed where jet or barometric condensers used. For this process, feed water heater, sludge or settling tank, filters, and chemical feeding device are required. One plant treats water for 9.8 cents per 1000 gallons.—*R. E. Thompson.*

Boiler Corrosion and the Treatment of Boiler Feed Water. A. WINSTANLEY. Dec. Meeting, Past and Present Mining Students Assoc., Wigan Mining and Technical College, 1923. Pitting is caused by: (1) sulphur liberated from calcium sulphide formed by reduction of calcium sulphate by carbon; (2) oxygen, either in presence or absence of carbon dioxide, action in both cases being cyclic; (3) acid liberated from animal or vegetable oils, or heat insulation by mineral oil; and (4) galvanic action between boiler steel and impurities contained therein. Considerably less salts remain in solution after treatment with barium hydrate than after lime soda. Latter method was employed in number of installations which showed pitting, and prevalence of sodium salts (particularly sodium sulphate) being noted, experiments were carried out to determine effect of concentrated solutions of these salts on boiler steel. Distinct pitting visible to naked eye, after 6 months exposure, and pitting visible under lens, after 9 months exposure, occurred in bars of new boiler steel suspended in boiler feed water which contained 18.62 and 9.74 grains sodium sulphate per gallon respectively, increasing to 1762.8 and 760.4 grains per gallon after normal period of running. Approximate weights of sodium sulphate and chloride required for saturation of water boiling under pressures up to 100 pounds were determined. For sodium sulphate the concentration varied from 26,465 grains per gallon at 10 pounds to 25,380 at 100 pounds, and for sodium chloride from 28,000 at 10 pounds to 22,040 at 40 pounds. It was noted that temperature of the water was in each case higher than that of the steam, the difference varying from 3° to 7.5°F., at 10 and 100 pounds respectively, for sodium sulphate, and 17.5°-19°F. for pressures of 10-40 pounds for sodium chloride. This increased temperature not only represents loss of heat but foaming is produced under such conditions. A factor of 10 is suggested for salts in solution, allowing a maximum concentration of 0.4 pounds per gallon, providing a margin for emergency. One-quarter pound of incrustants per square foot interior surface and 0.5 pound sludge calculated from analysis of feed water, is suggested as criterion for determining safe period of running.—*R. E. Thompson.*

Determination of Dissolved Oxygen in Small Samples of Water. L. W. WINKLER. *Z. Unters. Nahr. Genussm.*, 47: 257-259, 1924. *Chem. Ind.*, 43: 28, B 573, July 11, 1924. Amount of dissolved oxygen in water can be

accurately determined using samples of water as small as 25-30 cc. by man-ganous sulphate—potassium iodide method. Liberated iodine is titrated with 0.002 N thiosulphate solution. If nitrites are present they must first be removed by means of bleaching powder and potassium thiocyanate solutions. Very concordant results were obtained.—*A. M. Buswell.*

Action of Precipitated Iron Hydroxide on the Flora and Fauna of Natural Flowing Waters. H. J. KRAMER. *Z. Unters. Nahr. Genussm.*, 47: 148-168, 1924. *Chem. Ind.*, 43: 24, B 490, June 13, 1924. Summary is given of literature regarding action of iron on vegetable and animal organisms. The author's own investigations indicate that iron hydroxide precipitates in water pass into various parts of bodies of animals living in water through their digestive systems and have a toxic effect which eventually leads to complete depopulation of such waters. Forms most easily affected are those which derive their nourishment from the silt at bottom of water courses.—*A. M. Buswell.*

Water Purifying Apparatus. E. DECLERCQ. E. P. 210,437-8, 8.2.23, Conv. 10, 3, 22. *Chem. Ind.*, 43: 24, B 490-491, June 13, 1924. (A) In water softening apparatus comprising lime saturator and decantation tank with bases of conical form, raw water is delivered to base of saturator and decantation tank in such manner as to draw into system bubbles of air, which when released at apices of cones, serve to produce a mixing effect in lower part of tanks. Feed tube leading to base of a tank is furnished at its upper end with funnel-shaped mouth. (B) A sectionized filter disposed at upper part of a decantation chamber is provided with means for cleansing by a mixture of compressed air applied below the filter and softened water, the wash water being returned to the base of the decantation chamber.—*A. M. Buswell.*

Ground Firebrick for Furnace Repair. J. HARRINGTON. *Power*, 59: 25, 977, June 17, 1924. Mortar made up principally of same firebrick as used in wall itself; has identical mechanical and physical characteristics. Joints made with this mortar do not fire or flux, thus maintaining minimum brick surface to action of furnace gases and reducing opportunity for mechanical attachment of particles of ash blown or lifted from fuel bed. Mortar also used for facing or patching. Thick joints of this bond show saving of 35 per cent over thin cement joint construction.—*Aug. G. Nolte.*

Pulverized-Fuel Systems. A. L. COLE. *Power*, 59: 25, 985, June 17, 1924. Construction and operation of various systems used for conveying coal in pulverized form are illustrated and described.—*Aug. G. Nolte.*

Pulverized Anthracite Slush Burned at Lykens. *Power*, 60: 1, 2, July 1, 1924. Coal mixed with 75 per cent water, pumped 2500 feet under 400 feet head and dewatered at plant. By means of various scrapers, stackers and conveyors coal is conveyed to pulverizing house; then passed to double-shell driers where moisture is reduced to about 1 per cent. Screen test of slush as

fed to mills runs about 70 per cent through a $\frac{3}{4}$ inch screen; finished material leaving mills runs about 82 per cent through 200-mesh. From mills coal is discharged by conveyors to fuel bins above boiler aisle. Boiler plant contains six 5000 and six 6000 square feet water-tube boilers. Present generating capacity 6400 k.w. Combustion chamber is of special design. Each boiler fired by one special burner.—*Aug. G. Nolte.*

Hot Water Softener Saves over \$7000 a Year. J. E. DURFEE. Power, 60: 1, 11, July 1, 1924. The Buda Company, Harvey, Ill., installed hot-process continuous-type water softener with capacity of 12,000 gallons per hour. Raw water from artesian wells is augmented from Chicago mains; total incrusting solids of well water is about 49 grains per gallon; of Lake Michigan water about 9 grains per gallon. Water entering at top of softener is heated by exhaust steam to a temperature between 200 and 210°F.; then mixed with lime and soda-ash, automatically applied proportionally; then passed to sedimentation tank where it remains for about one hour, giving time for complete reaction and settling of the precipitated hardness. Boiler feed pumps take treated water from top of sedimentation tank, at which point it is freed from suspended matter by a quartz filter, and with 2 to $2\frac{1}{2}$ grains of hardness per gallon is delivered at a temperature of 200 to 210°F. Heat removes large part of calcium carbonate hardness, resulting in a daily saving of about \$3.25 in lime. Recent analysis showed a yearly saving of \$7322.50 was made by softener, a return of over 110 per cent on the investment.—*Aug. G. Nolte.*

The Evils of Close Regulation in Automatic Combustion Control. T. A. PEEBLES. Power, 60: 1, 13, July 1, 1924. Automatic devices are applied in many ways to processes involved in generating steam. Close regulation is desirable from viewpoint of production or utilization, but it tends to introduce wear, surging, and other undesirable conditions. Evils occurring to combustion-control apparatus are itemized and described.—*Aug. G. Nolte.*

Device for Holding Vertical Check Valve Open. E. L. WAY. Power, 60: 1, 14, July 1, 1924. A simple but practical device is illustrated and described.—*Aug. G. Nolte.*

Materials for Sealing Up Cracks in Castings and Cementing Joints. A. J. DIXON. Power, 60: 1, 23, July 1, 1924. A number of valuable pointers on this subject are given.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power, 60: 1, 28, July 1, 1924. Questions are asked and answers given on following subjects—Heat Equivalent to Horsepower-Hour; Shutting Down Steam Turbine; Action of Governors on Electric Elevators; Losses in Transformer; Calculating the Pressure in Hydraulic Elevator Cylinders; Computing Water Power from Second-Feet of Flow; High Working Pressures for Return Tubular Boilers; Running Blow-off Connections.—*Aug. G. Nolte.*

Pitting of Hydraulic-Turbine Runners. Power, 60: 1, 31, July 1, 1924. Comprehensive report is given. Conclusion is drawn from experience of operating companies that chief factor governing pitting of water wheels is total draft head acting on runner.—*Aug. G. Nolte.*

Iodine Deficiency and the Prevalence of Simple Goiter in Michigan. Public Health Reports, 39: 26, 1568, June 27, 1924. Fifty samples of water, 15 gallons each, were collected from localities representing whole state. Four counties then chosen as showing greatest difference in iodine content of water. Six samples of water from each county were collected and analyzed and goiter survey made in each county. Results are given in tabular form. Largest percentage of population with goiter was found in county in which iodine content of the water was least. More prevalent among girls than boys. Most prevalent among former at age of ten; among latter at age of twelve years. In regard to school standing, greater percentage of afflicted pupils were below school grade than of those not afflicted.—*Aug. G. Nolte.*

The Cross-Compound Turbine Adaptable to a Variety of Conditions. E. H. THOMPSON. Power, 60: 2, 50, July 8, 1924.—*Aug. G. Nolte.*

Determining the Type of Vacuum Pump for Given Air Removal Conditions. C. M. REED. Power, 60: 2, 52, July 8, 1924. Various calculations are made and a number of diagrams given.—*Aug. G. Nolte.*

The Diesel Engine in Medium-Powered Central Stations. R. C. BURRUS. Power, 60: 2, 54, July 8, 1924. Comparison made of operating and maintenance costs of small Steam, Electric and Diesel Engine Plants. Latter is most economical.—*Aug. G. Nolte.*

The Sphere of Boiler Compound—Colloid Chemistry and Scale Prevention. E. M. PARTRIDGE. Power, 60: 2, 56, July 8, 1924. Refutation is made to the oft met attitude that compound treatment is satisfactory only when waters of moderate hardness are concerned.—*Aug. G. Nolte.*

Questions and Answers. FRANKLIN VAN WINKLE. Power, 60: 2, 66, July 8, 1924. Questions are asked and answers given on following subjects—Internal Combustion Cycle; Variation of Water Level in Gage Glass; Load Taken by Induction Motor Operating in Parallel with Waterwheel; Operation of Centrifugal Feed Pump; Setting Valves of Buckeye Engine; Elevator goes up with the Controller on the Down Position; Size of Generator for 6 hp. Gas Engine.

The Cause and Control of Corrosion in Heating Systems. Power, 60: 2, 71, July 8, 1924. Tentative conclusions resulting from present incompletely investigations of Committee on Corrosion of National District Heating Association.—*Aug. G. Nolte.*

Coal Storage Report of American Engineering Council Made Public. Power, 60: 2, 75, July 8, 1924. Advocates uniform monthly deliveries; storage at point of use; gives figures on cost of storage; says cars should be assigned on basis of coal sold.—*Aug. G. Nolte.*

Safeguarding the Sanitary Quality of Drinking and Culinary Water Supplied on Interstate Carriers. E. C. SULLIVAN. Public Health Reports, 39: 27, 1620, July 4, 1924. Authority for supervision of water supplies used for drinking and culinary purposes by interstate carriers as exercised by United States Public Health Service is based on quarantine laws of the United States, enacted by Congress. Present regulations promulgated by Secretary of Treasury on May 3, 1921. Administratively, work is divided into following subdivisions; (1) periodic issuance of certificates of inspection, approving or disapproving use of water from various sources of supply on cars or vessels; (2) making of sanitary surveys of railroad coach and terminal yards; and (3) annual inspection of sanitary conditions on all passenger vessels operating in interstate traffic. Various phases of the work involved are described in this comprehensive paper.—*Aug. G. Nolte.*

Conductivity of Mineral Waters as a Means for Control. N. KOPACZEWSKI. Comptes rendus, 178: 2117-2120, June 16, 1924. Conductivity offers rapid and exact method for identification and control of mineral waters. Artificially prepared waters vary 15 to 20 per cent from natural water of same apparent composition. Experiments on number of mineral waters have shown that escape of carbon dioxide introduces very little error and it is not necessary to boil and filter the water to get an unvarying liquid.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Javellization of Water. F. DIENERT. Rev. hyg., 46: 245-260, March, 1924. Calcium hypochlorite recommended for large, and sodium hypochlorite, for small installations. Where over-chlorination is used, amount of $\text{Na}_2\text{S}_2\text{O}_5$ used is twice the amount of chlorine to be destroyed. Details of determination of amount of free chlorine by titration are given. Two methods of application are detailed.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Scientific Treatment of Boiler Water, Introducing the Colloidal Aspect. W. H. BANNISTER. Water and Water Eng., 26: 183, March 20, 1924. A very general paper discussing well known methods of boiler water treatment and containing references to "algor," apparently a colloidal proprietary substance used for boiler waters.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Water Sterilization by Ozone. M. SÉNEQUIER. La technique sanitaire, Nov. 1923, 310-3; Water and Water Eng., 26: 125, March 20, 1924. A general paper. Cost of treatment is worked out, making ozone cheaper in most cases than chlorination.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Standard Arrangements for Impulse Turbines. S. C. O'GRADY. Water and Water Eng., 26: 49-55, February 20, 1924. A discussion of pipe line and of characteristics of different turbines.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Strange Wells of Yucatan. ANON. Water and Water Eng., 26: 62-3, February 20, 1924. Water is obtained by the Indians from subterranean caverns reached by incredibly long and laborious complicated passages.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Municipal Swimming Pools and Shower Baths at Butte aux Cailles, Paris (France). A. BIDAULT DES CHAUMES. Le genie civil, 85: 53-9, July 19, 1924. Illustrated article giving engineering description of pool 12 m. by 33.33 m. and varying in depth from 0.75 to 2.75 m. Water is supplied from artesian wells.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Water Supply of Country Districts. CECIL H. ROBERTS. Water and Water Engineering, 26: 189-192, May 20, 1924. A general account of conditions in Great Britain including financial details. In England and Wales nearly 40 per cent of rural parishes have piped supplies.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

An Example of a Water Supply for a Modern Army. ANTONIO SARMIENTO. Memorial de Ingenieros del Ejercito, January, 1924, pp. 1-25; Water and Water Eng., 26: 252, June 20, 1924. Chiefly description of work of English in Mesopotamian campaign.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Water Purification for Industrial Purposes. J. P. O'CALLAGHAN. Water and Water Eng., 26: 303, 112, March 20, 1924. Description of Becton plant of Gas Light and Coke Co., on the Thames. Sedimentation followed by filtration through rectangular concrete mechanical filters at rate of 79 Imp. gallons per square foot per hour. Air and water wash is used for filters.—*Jack J. Hinman. (Courtesy Chem. Abst.)*

Relations Between the Variations of the pH of Sulphurous Waters and Their Changes in the Air. A. DESGRES, H. BIERY, and L. LESCŒUR. Compt. rendus, 178: 2213-7, June 30, 1924. In course of alteration of sulphurous waters in air, pH is sometimes lowered, as in Luchon waters, and sometimes increased, as in waters of Alps. It is said that there are two orders of phenomena viz., oxidation of the sulphur and exchange of gases. The first is noted in waters of Luchon, when end-result of contact with air, after more or less prolonged interval is pH drop, consequent upon change of sulphites to sulphates. One can conceive how a water of this sort, introduced into the body at pH above that of the blood, and there undergoing change to lower pH, may have therapeutic action.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Collapse of Perth, W. Australia, Filter Beds. Commonwealth Engr., 373-4, April, 1924; Water and Water Eng., 26: 291, July 21, 1924. Report of Govern-

ment Inquiry Board on collapse of N. wall and conduit system of filter beds showed faulty design and construction. Pillars supporting conduit collapsed pulling down the wall. Conduit should not have been attached to wall and wall should have been reinforced as designed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Circular of the Minister of Hygiene (France) on Prophylaxis of Typhoid Fever. PAUL STRAUSS. L'Eau, 17: 32-33, March 15, 1924. Circular to the prefects dated February 8, 1924, reviewing means of spread of the disease and calling attention to need for supervision of water supplies.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Making Swimming Pools Safe. JOSEPH GARDNER TEW. J. Nat. Ed. Assn., 13: 141-2, April, 1924. Description of pool of Hammond, Indiana, High School. Equipment includes pressure filters and ozone sterilizer. Daily tests of pool water are made.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Bacterial Examination of Beverages in Iowa. MAX LEVINE and J. H. BUCHANAN. National Bottlers' Gazette, 42: 158-9, February, 1924. When spoilage is characterized by heavy sediment, yeasts are most likely responsible, whereas with sediment lacking, or in small amount, bacteria from water supply are likely caused of spoilage. Carbonated beverages and waters are generally good. (See also Nat. Bottlers Gazette, 41: 170-4, 1923).—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Centrifugal Pump. M. HAKKERT. Water and Water Eng., 26: 307, 277, July 21, 1924. General description of its advantages and limitations.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water of Lemmel-Moll for the Province of Antwerp. ANON. L'Eau, 17: 52-3, May 15, 1924. Water from wells about 125 feet deep in sand will be supplied after deferrization to 35 communities.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report of the Goiter Commission of the Pediatric Society of Munich. C. SEITZ. Münch, Med. Wochenschrift, 70: 1406, 1923. Bull. mens. office international d'hygiène publique, 16: 633, May 1924. Review of local situation. Sensibility of children, at least to doses of $\frac{1}{2}$ mg. I per week is very slight. However, I ought not to be given except where goiter is actually epidemic.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On the Detection in Water and the Biology of B. coli. G. SALUS and G. HIRN. Centralbl. f. Bakt., 90: 286, 1923. Description of work with Eijkmann test. (Fermentation of dextrose broth incubated at 45-46°C. for 48 hours.) Claim only B. coli freshly from men, or from warm blooded animals or birds, regularly give test. Gas at 37°C. is not so definite.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Contribution to the Etiology and Prophylaxis of Endemic Goiter. GIACOMO PIGHINI. *Il Policlinico (Sez. pratica)*, 31: 452, April 7, 1924; *Bull. mens. office internat. d'hyg. publique*, 16: 632-633, May, 1924. Goiter is endemic in Secchia valley. Necessary to devise substance safe to put into hands of ignorant peasantry. Tablets were made up as follows; NaI 0.91 gr., Tinct. I 1 drop, dried thyroid substance 0.02 gr., chocolate or sugar coated. Cheap and satisfactory. Given one or two per week for children according to age. Three or four for adults. In grave cases of dysthyroidism or athyroidism author added to the tablets 0.02 gr. powdered testicular substance.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Contribution to the Prophylaxis of Goiter, by Iodine in the Schools. LUTZ. *Münch. med. Wochenschrift*, 70: 1120, 1923; *Bull. mens. office internat. d'hyg. publique*, 16: 633, May, 1924. In 30 children in Wollmatingen am Bodensee, where goiter is endemic, 16 showed hyperthyroidism at average age of 12 years. They received a tablet of proprietary compound, containing 0.003 mg. I, every week from November, 1922, to March, 1923. Goiter was then perceptible in but 2. No trouble was experienced with the treatment.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

The Material of Pipes. F. SATURNINO RODRIGUES DE BRITO. Report on sanitation of Uberaba, Brazil, 1922; *L'Eau*, 17: 29, March, 1924. Discussion of merits of cast iron and steel pipe. Quotes North American experience. Prefers cast iron pipe. (Also *La Revista Brasileina de Engenharia*, 4: 25, January, 1924.)—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Remarks on the Water Supply of Cities and the Country. J. SALMON. *Annales d'hyg. publiques, industrielle et sociale*, 1: 28 January, 1924. Attention is called to: (1) false security of old or technically uncontrolled water supplies; (2) Bad quality of water taken in congested or populated places (3) Possibilities of easy selection of adequately protected sites which may be reached at comparatively slight expense. Department officials should have more information available about present and future supplies of towns and villages of department.—*Jack J. Hinman, Jr. (Courtesy Chem. Abst.)*

Progress of Hose Coupling Standardization. J. H. HOWLAND. *Fire & Water Eng.*, 74: 1327, December 26, 1923. Complete sets of tools for converting the great majority of existing threads to universally adopted National Standard, lack of which had been outstanding factor in retarding progress in standardization, were first made available and tried out in May, 1919, in Hunterdon County, N. J. Two months later, threads in three municipalities in Indiana were completely standardized. Results obtained were so encouraging that organized movements for State-wide standardization followed; Michigan, New Jersey, Indiana, Minnesota, Ohio, and Rhode Island taking the lead. The movement is now organized in over one-third of the states. Since spring of 1920, nearly 800 municipalities have had their fire hose threads completely standardized. Approximately three-fourths of the 8000 protected cities and towns still have non-standard threads. Illus.—*Geo. C. Bunker.*

Assessment Vs. Bond Issue for Water Main Extension. P. DIEDERICH. Fire & Water Eng., 74: 1329, December 26, 1923. In Glendale, California, it was voted that cost of all service mains hereafter installed, up to and including 4-inch in diameter, and also, where a distribution main larger than 4-inch is used also for a service main, a part of the cost of such distribution main equal to the cost of a 4-inch main in the same location shall be paid by local assessment on property served by such mains. It has been found that front foot plan of assessment meets with less objections where property is subdivided into lots; but combination of area and per front foot can be used in some cases where lots are deeper on one side of the street than on the other, as these deeper lots will use much more water if cultivated, or where many houses can be built, as in bungalow courts.—*Geo. C. Bunker.*

Rebuilding a Water Works System to Meet City's Growth. C. L. EHRHART. Fire & Water Eng., 74: 1333, December 26, 1923. To meet increasing demand for water in Boone, Iowa, \$180,000 worth of bonds were voted for extension of water works. Sixty acres skirting the Des Moines river were purchased and pumping station and open reservoir of 1,125,000 gallons built. Ground water is obtained from 10 wells on island in river and is pumped into reservoir either by duplex steam unit or by electric motor-driven centrifugal. From reservoir, the chlorinated water is pumped through 20,000 feet of 4-inch pipe into 20,000 gallon tank, from which surplus runs into reservoir at the city station of 3,333,000 gallons capacity. At night when river station is not in operation automatically controlled electrically driven centrifugal delivers water into the above tank, as required. Night pumping is to be eliminated later by construction of larger elevated tank. The C. & N. W. Railway takes about 60 per cent of water, or 600,000 gallons per day. The other 2400 services are metered, and average consumption (including railroad) is about 85 gallons per capita per day—*Geo. C. Bunker.*

Copper Sulphate Treatment of a Mass. Water Supply. E. S. CHASE. N. E. W. W. Assn. January, 1924. Eng. Contrg., 61: 577-83, 1924. Describes methods and results in handling pond of surface area 43 acres, 23 feet maximum depth, containing 85 million gallons water. By dosing, organisms could be kept below 1000 per cubic centimeter preventing tastes and odors. 0.6 to 0.7 p.p.m. of CuSO_4 proved most effective.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Water Motors Inject Chlorine at Moncton, N. B. J. VAN BENSCHOTEN. Can. Engr., 46: 281-2, 1924. Eng. Contrg., 61: 589-91, 1924.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Water District for Westchester County. NICHOLAS S. HILL, JR. Pub. Works, 55: 157-9, 189-90, 1924. Discusses plans for present and future of suburbs by means of commission with broad powers to acquire supplies, condemn lands, and sell water wholesale to communities.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Hydrogen-Ion Control in Water Purification. Mass. State Board of Health, 1922; Eng. Contrg. 61: 113-4, 1924. Method of loading a slow sand filter with $Al_2(SO_4)_3$, or with other chemicals, is discussed.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Hydrogen-Ion Correction at Waterford. R. G. YAXLEY. Pub. Works, 55: 145, 1924. Use of commercial H_2SO_4 , 66°Be., in amounts of 0.8 grain, cut alum dose from 4 to 3 grains, giving floc. Raw water is from Hudson River.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Chlorine Cures Bad After-Effects of Copper Sulphate. Edit. Fire and Water Eng.; Eng. Contrg., 51: 76, 1924. After-odors from synura destroyed by $CuSO_4$ were removed by Cl in New York City.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Present Status of Sanitary Engineering. H. P. EDDY. Am. Soc. C. E.; Eng. Contrg., 61: 83-8, 1924. Can. Engr., 45: 387-9, 1924. Very complete review, with suggestions for research.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Effect of Continuous Treatment of Water in Settling Basins at Council Bluffs. J. B. THORNELL. Ann. Rep., 1923; Eng. Contrg., 61: 1093-4, 1924. New settling basins helped keep down turbidity, reducing cost of chemicals.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Outdoor Swimming Pools. S. PINEL. Eng. Contrg., 61: 1066-75, 1924. Covers design in detail, with suggestions on operation.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Sacramento's Filtration Plant. Pub. Works, 55: 51-4, 1924. Has a capacity of 48 million gallon per 24 hours and cost \$2,700,000. Alum is manufactured, as also electrolytic chlorine. Raw water is aerated, coagulated with mechanical agitation, settled, and filtered in 8 units.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Columbus Water Works Notes. C. B. HOOVER and C. P. HOOVER. Ann. Report, 1923. Pub. Works, 55: 187-8, 1924. Of 45,208 active services, 44,749 were metered. Hardness was reduced from 265 to 95 parts per million, at cost for chemicals of \$19.47 per million gallons. Turbidity was reduced from 90 to 0 p.p.m. and color from 24 to 2 p.p.m. Experiments on carbonation were carried on, using chimney gases, pre-washed. For coagulation, velocities between 0.3 and 0.6 feet per second are suggested; on turbid water, coagulation results with lower velocities, if excess coagulant added; mixing for 20 to 30 minutes at 0.6 feet per second is more effective than 1½ hours at 0.3 foot per second. Mechanical agitators are less expensive than baffled mixers. Bacterial results on treated water; 20 positive presumptive tests for *B. coli* in 10 cc. for year, 12 occurring in January.—*Langdon Pearse*. (Courtesy Chem. Abst.)

Alum Feeding Machine for Water Treatment. F. M. VEATCH. City Manager Mag., 1924. Eng. Contrg., 61: 557-9, 1924. This machine builds a solution feed.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Free Chlorine in Drinking Water. W. OLSZEWSKI. Chemiker Zeitung. Eng. Contrg., 61: 562-3, 1924. If free Cl amounts to 0.02 to 0.04 mgm. per liter, no taste or odor is caused. For detection of free Cl author recommends Raschig's solution of benzidine in HCl, describing tests. Cf. this Journal 11: 3, 732.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Function of Aeration in Water Purification. MALCOLM PIRNIE. Indiana San. & W. S. Assn., 1924; Eng. Contrg., 61: 573-6, 1924. Effects of aeration are described under conditions prevailing respectively at Watertown, N. Y., West Palm Beach, Fla., Danville, Va., Long Beach, L.I., N. Y., Albany, Poughkeepsie, and Providence, R. I. Aeration is useful for removing taste, aids in coagulation with soda ash, removes iron.—*Langdon Pearse. (Courtesy Chem. Abst.)*

A Simple Method of Determining Pump Slippage. J. F. PIERCE. Eng. Contrg., 60: 1226-7, 1923. By use of Pitot tube in discharge, with manometer and counter, discharge and slip of piston pump was computed.—*Langdon Pearse. (Courtesy Chem. Abst.)*

Measuring Water with Salt. C. M. ALLEN. Eng. Contrg., 60: 1230, 1923. By introducing salt under pressure into a pipe, time of flow can be determined from conductivity measurements at electrode sets spaced at convenient distance apart.—*Langdon Pearse.*

The Advantages of Small Cast Iron Pipe for Water Services. J. R. MCWANE. Fire & Water Eng., 75: 13, January 2, 1924. Advantages and description of installation of McWane cast-iron service pipe, 1½-inch and 2 inch sizes, with special service connections. Precalked joint is also described. Illus.—*Geo. C. Bunker.*

Oil Engine Operating Cost Half of Steam, Water Works Finds. F. JOHNSTONE-TAYLOR. Fire & Water Eng., 75: 27, January 2, 1924. Data regarding performance of Diesel engine, working parallel with modern steam plant for Alexandria (Egypt) Water Company, taken from paper presented by engineer of Company before British Diesel Engine Users Assoc.—*Geo. C. Bunker.*

How Meters Affect Rates and Consumption. E. I. ROBERTS. Fire & Water 75: 61, January 9, 1924. Study of meter rates and installations in 150 cities and villages in Ohio. For 100 per cent metered cities and villages average daily consumption is 90 gallons per capita; for unmetered cities and villages, 170 gallons per capita. For cities alone, population 5000 and above, 100 per cent metered, average daily consumption is 100 gallons per capita. Average domestic rate is slightly higher for filtered surface water than for well water, while average manufacturing rate is, on the contrary, slightly less for filtered water than for well water. Details are given in tables.—*Geo. C. Bunker.*

Simplified Mathematics for the Practical Water Works Man. E. J. ROWE. *Fire & Water Eng.*, 75: 65, January 9, 1924. Recommends use of logarithmic cross section paper for determining grains per gallon of alum, parts per million of chlorine, volume of wash water, etc. Illus.—*Geo. C. Bunker.*

What Water Works Men Should Know About Flush Valves. W. KING FLAVIN. *Fire & Water Eng.*, 75: 111, January 16, 1924. Flush valve effects economy in consumption of water; but no series of tests are on record covering any extensive period of time, or installation. Probable causes of economy may be listed as: (1) more pressure available; (2) consequent greater variations in flush obtainable; (3) fewer repairs needed. Possibility of siphonage of bowl contents into drinking water supply is discussed. Illus.—*Geo. C. Bunker.*

Simple Method of Handling Concrete in Reservoir. ROBERT E. McDONNELL. *Fire & Water Eng.*, 75: 158, January 23, 1924. New Reservoir, 13,500,000 gallons capacity, for Grand Junction, Colorado, has earth embankment with reinforced concrete lining. Side slopes are $1\frac{1}{2}$ to 1. Slabs on side slopes are 6 inches thick, with membrane water-proofing 2 inches from surface. Bottom of reservoir, covering about 2 acres, is of 5-inch concrete slabs 20 feet square, resting on concrete beams at joints: beams being water-proofed and holding water-proofing joint material between edges of slabs. Slabs on slope and bottom were put in on alternate sections. Platform from which concrete was discharged was placed on wheels at toe of slope so as to be readily movable. Concrete discharged on top of platform was moved into place through flexible chute. Approximate cost, \$75,000. Very brief account with 3 views of work.—*Geo. C. Bunker.*

An Up-to-Date Filtration Plant. ALBERT GIVAN. *Fire & Water Eng.*, 75: 161, January 23, 1924. Raw water for Sacramento, California, filtration plant is taken from intake in Sacramento river one fourth mile below its confluence with American river, whence it will flow either by gravity direct, or by siphonage, depending upon stage of river, through riveted steel pipe line into well in pumping station which consists primarily of 75 feet diameter concrete caisson, in which all pumping equipment is installed, beneath 79 by 128 feet building. Five pumps, total capacity 80 m.g.d. will lift raw water to filtration plant; and provision has been made for 8 additional 25 m.g.d. units. Five high lift pumps, total capacity 90 m.g.d., will supply filtered water to distribution system and provision has again been made for 8 additional 25 m.g.d. units. Two wash water pumps, 2 drain pumps, and 2 small sump pumps complete the equipment, all pumps being of motor driven centrifugal type. Electric circuits of station are controlled from 10-panel remote-control benchboard arranged in arc and standing on dais 21 inches above main pump floor. On sub-base of benchboard are hand wheels for operating 4-way valves controlling hydraulic valves on suction and discharge lines. At right of benchboard are five panels which carry gauges indicating water-levels, rates of flow, pressures, etc. Pump station is arranged electrically in duplicate, and power is taken from the two large companies serving this

district; it is also arranged hydraulically in duplicate. Various details are given concerning electrical equipment. Title of article is misleading inasmuch as only pumping station is discussed. Illus.—*Geo. C. Bunker.*

NEW BOOK

Of What Will the Pipes of To-morrow be Made? Of Cast Iron or of Steel?
LEON BONNET. Librairie Polytechnique Ch. Beranger, 15 rue des Saints Pères Paris (VI) 8vo, 172 pages, 15 figs. (Noted by L'Eau.)—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)